GLASS OF THE ROMAN WORLD

Edited by Justine Bayley, Ian Freestone and Caroline Jackson

Frontispiece: Jenny Price

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JUSTINE BAYLEY, IAN FREESTONE AND CAROLINE JACKSON

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consolidate aspects of our understanding of how glass was produced, traded and used throughout the Empire and the wider world
drawing on chronology, typology, patterns of distribution, and other methodologies, including the incorporation of new scientific
methods. Though focusing on a single material the papers are firmly based in its archaeological context in the wider economy of the
Roman world, and consider glass as part of a complex material culture controlled by the expansion and contraction of the Empire'
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PREFACE

In 2006 a two-day conference in honour of Professor Jennifer Price was organised by the Association for the History of Glass (AHG) to mark her retirement from a personal chair in the Archaeology Department at Durham University. The papers given at the meeting were wide-ranging, and those collected here reflect aspects of research on Roman glass, a subject in which Jenny has been central for over 40 years. The conference paid tribute to her and her work, and we hope this volume will do the same as well as providing a starting point for new research, both by those who have worked with Jenny and been influenced by her contributions to glass studies, and by those new to the field. Indeed, as can be seen by the continuing list of Jenny's publications, she is still active so we hope for many more years of work on glass under her influence and generous guidance.

Roman glass studies have historically been influenced by the research of distinguished scholars such as Isings, Fremmersdorf and Harden, the latter in particular was Jenny's mentor. Jennifer Price's work has derived from this tradition. Her knowledge of glass, from many historical periods and geographical regions, not only Roman, is impressive. However, her work is also firmly established in the archaeological roots of the discipline and reflects its intellectual and theoretical perspectives.

The authors of the 18 papers in this volume mirror many facets of Jennifer Price's research and scholarship. Some write about a problem grappled with by her (Fontaine and Foy, Newby) while others draw on a group of material she has published in detail (Cottam, Hoffmann, Jennings, Israeli). They also address glass manufacture (Nenna, Follmann-Schulz, Shepherd, Whitehouse) and topics she has written about to great effect, such as the integration of scientific data with that on glass forms and distributions (Jackson and Foster, Freestone and Stapleton). Other papers present topics which complement her research, running parallel to it and use and feed back into her stylistic and contextual research (Amrein, Fünfschilling, Stern, Keller) or build in related areas (Bayley, Cosyns). In this way, each author has touched upon Jenny's methods, her extensive knowledge and published data, to extend and pull together aspects of what we understand of how glass was produced, traded and used in the Roman world.

The Editors

INTRODUCTION

Jennifer Price and her Contribution to the Study of Roman Glass

For over forty years, Jennifer Price has been making substantial contributions to our understanding of Roman glass, not only in Britain, but across the Roman world, as may be seen from the list of publications below. Her contributions extend way beyond her own writings; most of those now active in glass studies have benefited from Jenny's insights into their material and their interpretations.

Jenny comes from a family of glassmakers in Stourbridge, Worcestershire and joined an evening class in archaeology while at high school, excavating local sites at weekends under Graham Webster, the Roman archaeologist and pottery specialist. From this point it might be expected that her future was decided, but at the time it must have appeared as if Jenny was destined for a successful career in the legal profession. On leaving school in 1958, she joined the Civil Service, working for the Inland Revenue, while studying Law. Soon after being called to the Bar in 1963, however, she seems to have decided that archaeology was for her, and spent three years from 1964–66 working on excavations in southern Italy and in Israel, notably at Masada where one of her tasks was the reconstruction of some of the glass vessels. In 1966 she enrolled at University College Cardiff, University of Wales, for a BA in Archaeology and on graduating in 1969, spent three years travelling and collecting material for her PhD on Roman Glass in Spain.

In 1972–73 Jenny worked for a year in the British Museum before returning to Cardiff for four years to teach prehistory for Richard Atkinson, while he served on the University Grants Committee. She then became Keeper of Archaeology in the Salisbury and South Wiltshire Museum until in 1980 she was appointed as Lecturer in Archaeology in the adult education department of Leeds University. She remained there for ten years, teaching adults in west and north Yorkshire, while there she also established the English Heritage-funded Romano-British Glass Project, which incorporated a very productive partnership with Hilary Cool. In 1990 she moved to the Department of Archaeology at Durham, where she taught Roman provincial archaeology and archaeological glass studies. During her time at Durham she was promoted to a personal chair and spent three years as Head of Department, retiring in 2005.

Jenny's work is characterised by a thorough and systematic approach to the artefacts, underpinned by a strong understanding of their archaeology and cultural context. It is an approach she patiently tries to instil in others and deviation from academic rigour is pointed out in a way which does not cause offence, but which can leave the recipient in no doubt of her opinions. The opening line "I think you are flying a kite here…" – loosely interpreted as "you are talking unsubstantiated nonsense" – is one such comment which mildly scolds but is given with humour and encouragement. Her generosity with her time and expertise is much appreciated by all who come into contact with Jenny, not least her students, a number of whom are specialists in their own right, building on the foundations she provided, not just in

the glass of the Roman period but also in medieval and early modern glass, and have moved onto academic positions in their own right.

Jenny has given a great deal to voluntary organisations concerned with archaeology and glass. She has served on the Council of the Society of Antiquaries, and as President of the Association Internationale pour l'Histoire du Verre. She was one of the founding members of the British Association for the History of Glass and led it through the planning and hosting of the very successful AIHV Congress in London in 2003. There is little doubt that this congress owed a great deal to Jenny's vast experience as a conferencegoer. Where there is a meeting on Roman glass, she will be there, keen to meet the young scholars coming into the field and to catch up with the more established colleagues. Her enthusiasm for her subject knows no bounds and this is passed on to all who come into contact with her. This summing up of her career however, is no conclusion to her work in the field. Retirement has not dampened her passion in any way, and we look forward to many more publications, interventions and convivial social occasions.

THE WORKS OF JENNIFER PRICE (TO DATE)

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Section 1: Technology and Production

1

PRIMARY GLASS WORKSHOPS IN GRAECO-ROMAN EGYPT: PRELIMINARY REPORT ON THE EXCAVATIONS OF THE SITE OF BENI SALAMA, WADI NATRUN (2003, 2005–9)

Marie-Dominique Nenna

For Jenny, guardian angel on my glass path

Introduction

In 1992, an exceptional discovery was made at Bet Eli'ezer in Israel (Gorin-Rosen 2000): seventeen tank furnaces were unearthed and identified as primary glassmaking furnaces where a mixture of sand and soda was melted in a one-phase process in a reverberatory furnace. The glass slabs were broken up in chunks, which were transported to secondary glass working workshops in which objects were made. The furnaces, laid side by side in rows, are all divided in two parts: two firing chambers of triangular form and a melting tank of 4 by 2m. Only the floors of the firing chambers and of the tank were preserved and based on this, and the fact that part of the remaining walls were built with reused bricks, the excavators assumed that each furnace was dismantled after the firing to allow the glass slab to be broken up. The site seems to have been in use for a short period; then the glassworkers moved to another location. The activity on the site was initially dated to the 6th-7th century AD, but analysis of the glass objects coming from consumption sites suggests this phase could be extended to the beginning of the 8th century (Freestone *et al*. 2000, 71–72).

This excavation has led to a reappraisal of the interpretation of the 8.8 tonne glass slab (dimensions of 3.40m × 1.95m × 0.50m) discovered in a cistern in Bet Shearim, which had been dated to the 4th-6th century AD (Brill 1967). The new study (Freestone and Gorin-Rosen 1999) has proposed, on archaeological and analytical grounds, dating this glass slab to the beginning of the Islamic period (early 9th century AD). The glass slab was left *in situ* because it was an enormous defective piece. Other primary glass furnaces of this type were unearthed in Apollonia in the 1950s and more recently (Tal *et al*. 2004).

All these furnaces are dated to the end of Antiquity and to the beginning of the Islamic period. Indeed, this type of tank furnace was still in use well into the Islamic period, as shown by the study of the furnaces of Tyre (Aldsworth *et al*. 2002) dated to the 10th-11th century AD. In all cases, except Tyre, only the floors of the furnaces are preserved and there is no information available on the elevation of the walls or on the form of the roof.

These discoveries have led to the development of the concept of two stages of production, with primary and secondary glass workshops which were located in different places during Graeco-Roman antiquity (Nenna *et al*. 1997). Various shipwrecks of the Hellenistic and Roman period (for example Sanguinaires A, dated to the 3rd century BC; Mjlet to the end of the 1st century AD and Embiez to the end of the 2nd-beginning of the 3rd century AD) have shown that raw glass was shipped during classical antiquity (Foy and Nenna 2001b; Fontaine and Foy 2007; Cibecchini *et al*. 2012); these represent the first stage of production. Glass coming from the Orient was certainly used in Central-Western European secondary glass working workshops of the Hellenistic period (Němčice: Venclovà 2009; Manching: Gebhardt 2010). However, the sources of raw glass used during the Early Roman period in the western provinces are still in debate from an analytical perspective (Picon and Vichy 2003; Freestone 2006, 211–212; Leslie *et al*. 2006, 264–266). It should be stressed that, to date, even though Pliny the Elder is explicit about their existence (Freestone 2008), no primary glassmaking furnaces of importance have been unearthed in Western Europe, and that the two main primary production centres are located by the Ancients in the eastern Mediterranean; in Egypt and in the Levant. In the Late Roman period, glass from the Levant (Levantine 1, Levantine 2) and from Egypt (HIMT group) were competing to supply the secondary glass workshops of the Empire (Foy *et al*. 2003b; Freestone 2005; Nenna 2014).

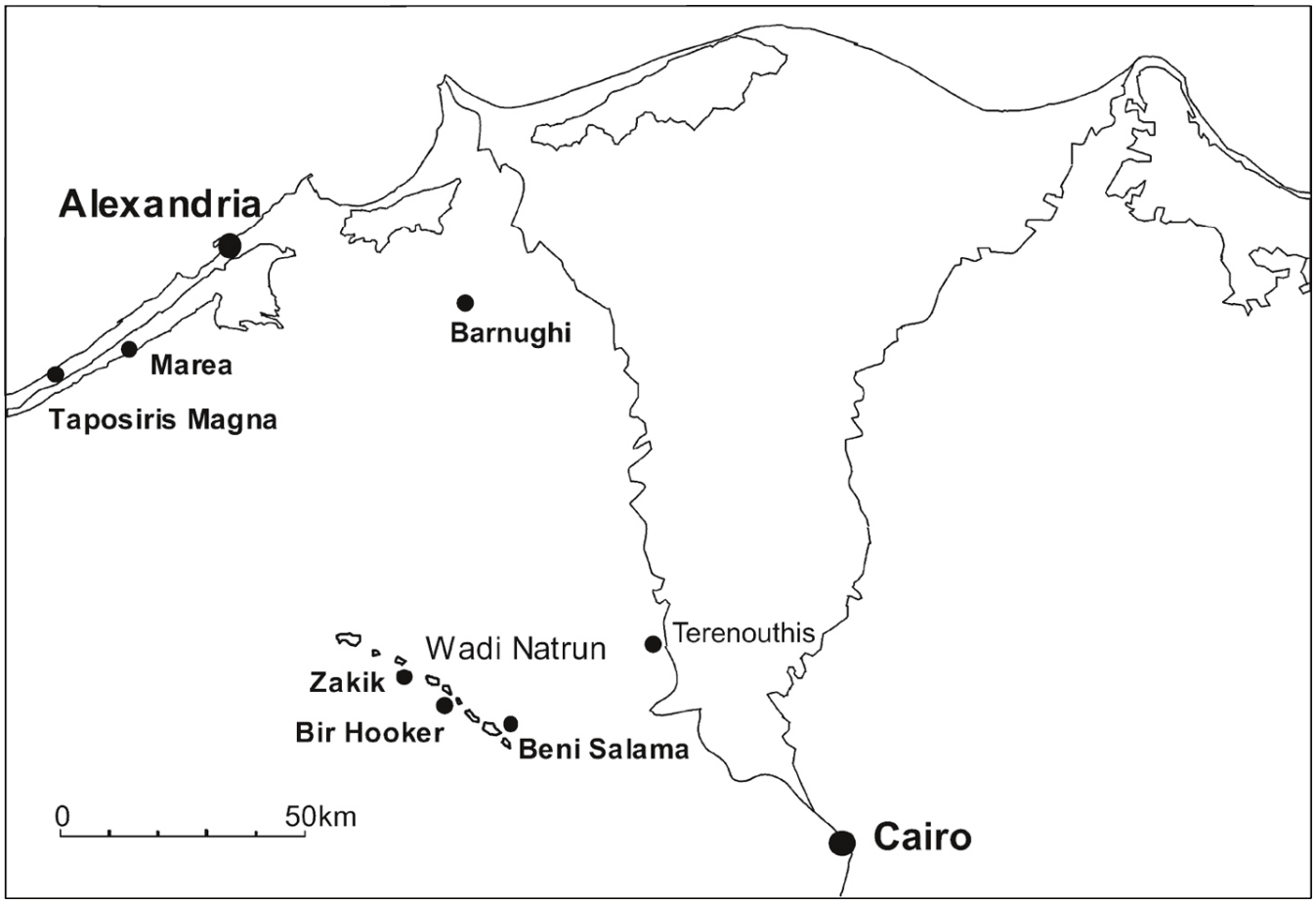

Fig. 1.1: Map of the northern part of Egypt.

Following the discovery of Bet Eli'ezer, in 1996 I initiated a project on primary glass workshops in Graeco-Roman Egypt, searching for sites which could have held such structures and hoping to define the characteristics of the glass industry in the country to which the Ancients attributed a wealthy and successful glass industry, but in which the archaeological remains connected to this craftsmanship were very scant at the time. From field surveys in the region around Alexandria, the Mareotid, and in Wadi Natrun, a depression with salt and natron lakes between Alexandria and Cairo, we could identify five primary glass workshops sites (Fig. 1.1), two in Mareotid (in Taposiris Magna and Marea-Philoxenité) and three in Wadi Natrun (in Zakik, Bir Hooker and Beni Salama). We were also able to recognize that the raw glasses produced in those two regions differed in composition and also differed from the raw glass widely distributed in the western provinces of the Roman Empire (Nenna *et al*. 1997; 2000; 2005, Thirion-Merle *et al*. 2003). The identification of these sites was made possible by the presence of surface finds of tiny raw glass fragments, of larger blue-green glassy chunks of poor quality, of bricks covered with a thick vitreous material which had a fractured surface suggesting that glass has been broken off, and others bearing an irregular blue-green vitreous layer. These characteristics are evidence for the presence on these sites of primary tank furnaces in which a glass slab was made and broken up in chunks for transportation, like those discovered at Bet Eli'ezer.

We chose to concentrate on the Wadi Natrun sites, which seemed to be the more promising, and conducted geophysical surveys. In Zakik, a site already known by scholars of the Expedition d'Égypte, and by the Egyptologist Gardner Wilkinson (Nenna *et al*. 2000, 100–102), the geophysical survey showed no structures, as the site had been reoccupied at the beginning of the 19th century by natron workers and the upper antique layers disturbed. However, surveys of Bir Hooker (Nenna *et al*. 2005) and Beni Salama (Fig. 1.3) revealed similar and very distinctive magnetic anomalies shaped like staples, approximately 8m long, with two 2m appendages at right angles. A systematic survey of the pottery, glass and faience from the sites showed that in Zakik, in addition to the Ottoman material, other finds are dated to the Hellenistic and Early Roman periods. At Bir Hooker, the findings of the survey and a small excavation we led in 2004, indicated that the occupation spanned the period between the 3rd century BC and the end of the 2nd century AD (Nenna 2005, 194–198; Marquié 2007).

The site of Beni Salama (Fig. 1.2) situated on the southern edge of the village of the same name, at the eastern entrance to the Wadi Natrun depression, is one of the few ancient sites of the region which is known through archaeological literature because of the presence of the remains of a temple of the Middle Kingdom (Fakhry 1940) and because of an initial study in the 1970s of the remains of the glass industry (Saleh *et al*. 1972). It is divided into two parts; in the northern area are two mounds, showing magnetic anomalies, comprising the waste from the glass workshops. In the southern area, on a higher plateau, there is an occupation zone, with the remains of a fortress and of a temple of the XIIth dynasty, which was in use from the Middle Kingdom until the 7th century AD, indicated by an examination of the pottery, glass and faience (Marquié 2007).

Beni Salama Excavations

The excavations in Beni Salama took place in 2003 and between 2005 and 2009. We present here the preliminary results, and for further details refer the reader to the exhaustive publication, in progress, which will appear in the *Études Alexandrines* (for preliminary reports,

see Nenna 2007a; 2009; 2010 for the 2005–2007 campaigns; the reports of the succeeding campaigns are in press in the *ASAE;* see also Nenna 2007b, 127–130; Nenna 2008, 61–62; *Orientalia* 77.3, 2008, 248–250).

On the southern hill of the industrial zone, we opened two excavation areas around the two magnetic anomalies (Fig. 1.3): sector 1 in the eastern part (416m^2), sector 2 (260m^2) in the western part. In sector 1, the magnetic anomaly is in the form of a rectangle: after digging, we understood that it corresponds to two different tank furnaces orientated in approximately the same direction: in the eastern one, the western wall of the tank was dismantled to break up the glass slab, in the western one, the eastern wall was dismantled. In sector 2, the staple-shaped magnetic anomaly corresponds to a tank furnace, the western wall of which was dismantled.

The configuration of the surface layers of the two sectors are different (Fig. 1.4). The furnaces of sector 1 are situated in a hollow in the hill; opposite, the furnace of sector 2 is on the slope of the hill. Sector 1 has thus been transformed into a sort of basin, the upper layers of which are impregnated with salt and petrified (natural and man-made) to a depth of up to 1.20m. In contrast, erosion, probably due to the wind and high daily fluctuations in humidity, has removed the upper part of brick structures in sector 2, particularly in the north of the sector, and the petrified layer here is thinner.

The excavation of sector 1 has taken a long time because of the complexity of the structures, which include:

- the presence of two furnaces built side by side; the western one, and possibly the eastern one too, shows three phases of activity.
- a weakness in the structure of the north-eastern angle of the western tank, which has forced the glassworkers to build and rebuild supports.
- the partial reoccupation of the sector after the glassmaking phases while the vault of the last western furnace was still partly standing, which has caused deep destruction to the northern part of the western furnace, but has allowed us to reach the foundation levels of the tank.
- the transformation of the northern part of the zone into a brick dump during the phase of abandonment.
- the presence of a thick salty layer covering all the remains and embedding some of them; it seems that this layer might be connected to activities related to the treatment of salt and natron.

In sector 2, the excavation has shown that roughly the same location was reused four times for building the furnaces, and that an earlier now very fragmentary furnace existed on the eastern side. The erosion of the northern part of the main furnace has prevented us from understanding the full plan of the firing-chamber, and in the tank the hardness of the floors has not allowed us to reach the foundation levels. Much later (around the 6th c. AD), within a phase of cessation of glass activities, the southern part of the sector was used as a rubbish dump, rich in amphorae, pottery and basketry, probably coming from the cleaning of Early Roman domestic contexts, situated on the plateau.

More generally, the fact that the same location was used three times in sector 1 and four times in sector 2, implies that we had to look for a succession of foundation trenches and dismantling trenches connected to one of the long walls of the tank. We also had to find evidence for the raising of the other walls of the tanks, of the level of the firing-chamber and the raising or the moving of the "clean" zone (see below).

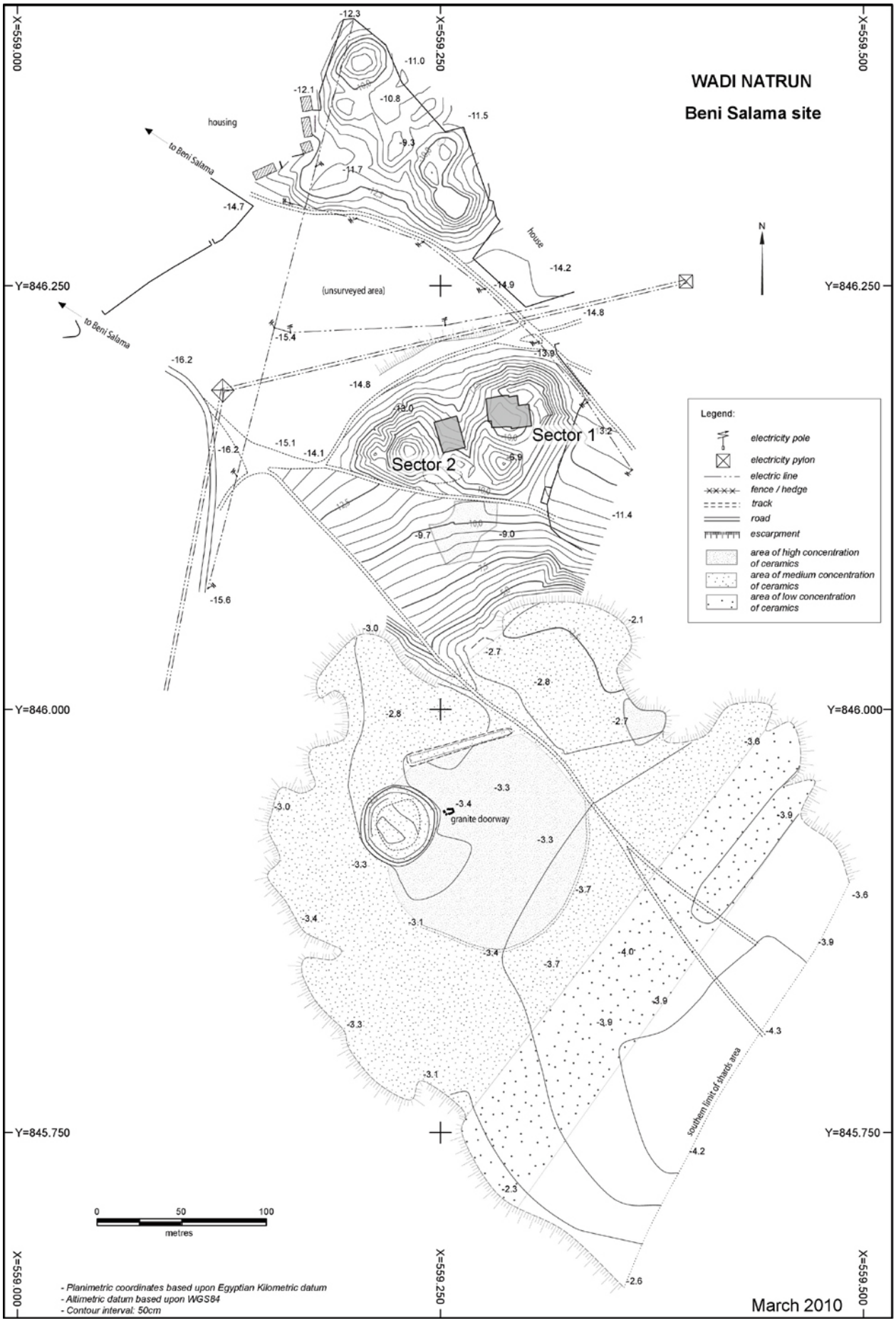
WADI NATRUN
Beni Salama site
X=559.000
X=559.250
X=559.500
Y=846.250
Y=846.000
Y=845.750
housing
to Beni Salama
to Beni Salama
house
(unsurveyed area)
Sector 1
Sector 2
granite doorway
southern limit of sherds area
N
Legend:
electricity pole
electricity pylon
electric line
fence / hedge
track
road
escarpment
area of high concentration of ceramics
area of medium concentration of ceramics
area of low concentration of ceramics
0
50
100
metres
- Planimetric coordinates based upon Egyptian Kilometric datum
- Altimetric datum based upon WGS84
- Contour interval: 50cm
March 2010

Fig. 1.2: Topographical map of the site of Beni Salama. MAWN, N. Martin and C. Shaalan.

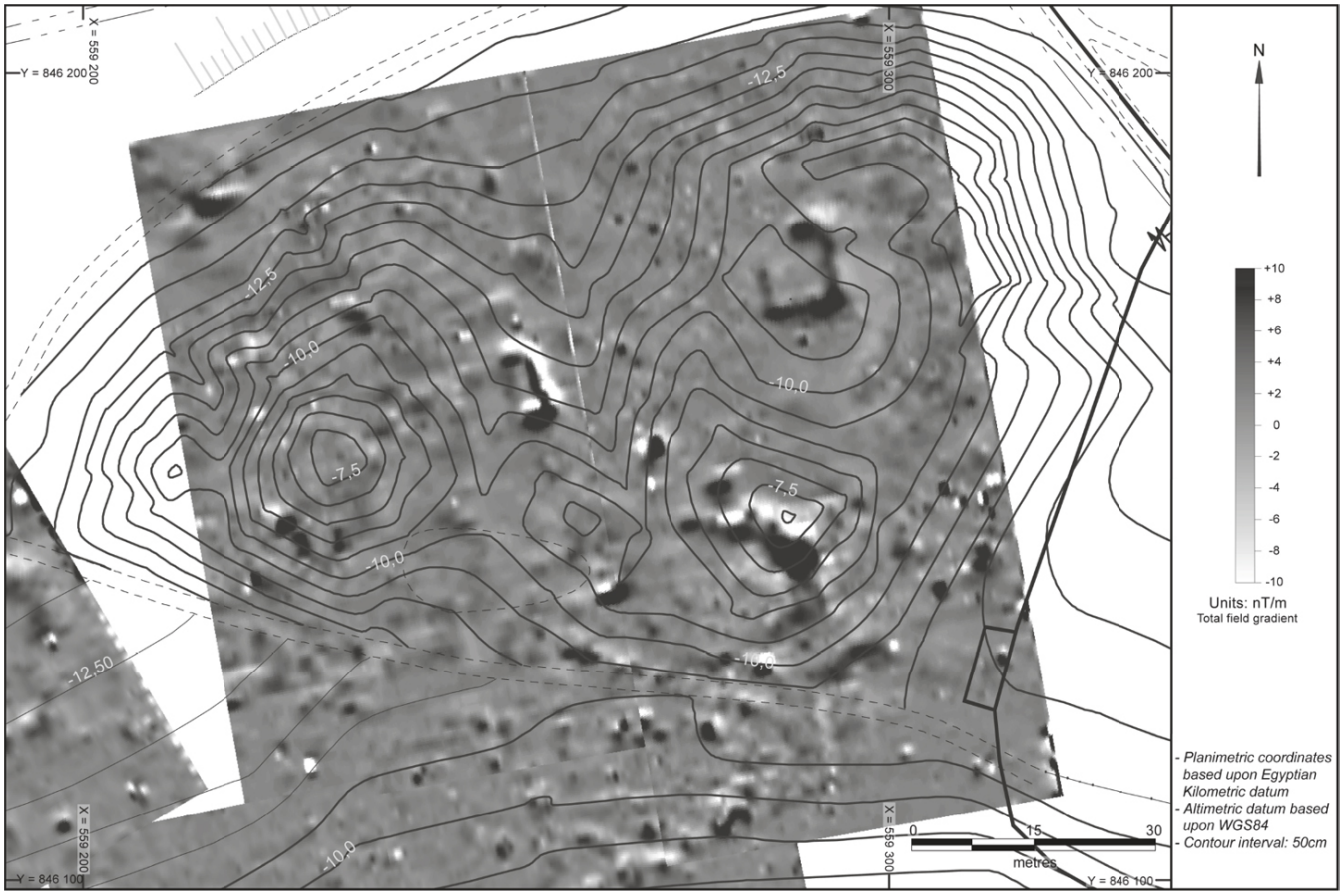

Fig. 1.3: Geophysical map of the southern hill of Beni Salama. MAWN, C. Benech and C. Shaalan.

Fig. 1.4: View of the excavations from the west, in the foreground sector 2, in the background sector 1, both located at the top of the hill. MAWN, M.-D. Nenna, 2006.

Fig. 1.5: View from the north of the whole of sector 2 with the last glass furnace, in the foreground the firing-chamber, in the background the tank of which the west wall was dismantled and the remains of the approaching platforms. MAWN, E. Thivet, 2007.

The information we can draw out from the excavation of each furnace is fragmentary, but put together it helps us to propose a reconstruction of the type of furnace in use in Beni Salama.

The plan of the furnaces

The furnaces are composed of three principal units: the firing-chamber, the tank, and a "clean" zone paved with bricks outside the furnaces, linked with ramps for bringing raw materials to the furnaces. Firing-chambers and tanks, in all cases, are orientated in the same north-west to south-east direction and open towards the predominant wind coming from the north-west.

The tanks are huge: their internal dimensions are 7 × 2m for the final furnace of sector 2 (Fig. 1.5), 6.10 × 2m for the western furnace of sector 1; the eastern furnace of sector 1 was not fully excavated, so its total internal length is uncertain, its width is 2m. The thickness of the floors are around 0.40m, and they are formed of layers of packed clay and may have also had a layer of square bricks on the top (none has been found in situ, but traces remain in the eastern furnace of sector 1). They seem to slope upwards slightly towards the south. When not intentionally destroyed in antiquity, as in the case of the western furnace of sector 1, they are extremely hard to break today, as in the case of the main furnace of sector 2. In the trench excavated in the centre of the tank, we reached the floor of the initial tank, which was

covered with a layer of broken glass, at 1m below the floor of the fourth and final tank. The second and third floor could only be seen in stratigraphic section (Fig. 1.6). The walls are very thick: the long walls are up to 1.80–1.90m, the back walls are up to 2–2.50m, the northern wall connected to the firing-chamber is around 0.40–0.50m. What is preserved of the walls indicates that they were around 1m high. They were built with different types of brick: in sector 1, the back wall of the western furnace is built of previously unused mud bricks (Fig. 1.7), but the exterior of the back wall of the eastern furnace is built with reused large rectangular bricks (Fig. 1.8); in sector 2, the back wall of the last furnace is made up of three parallel parts, each built with different types of bricks. The long wall which remained standing during the various phases of activity is built with large rectangular bricks, but the long wall which was dismantled at the end of firing to gain access to the glass slab was probably formed in a different way, using bricks on the interior of the furnace, but redfiring clay, in some cases strengthened by reused bricks, on the exterior. This practice probably facilitated the dismantling of the furnace, as shown by the remains of the eastern furnace of sector 1 (Fig. 1.9) and by the main furnace of sector 2. The key to understanding the form of the vault was the meticulous recording of the more than 500 bricks belonging to the collapse of the vault of the western furnace of sector 1 (Fig. 1.10), as well as the study of the lower part of the vault preserved on the western wall of this furnace. This structure comprised a flattish barrel vault mainly made up of rows of four curved bricks of two different types (Fig. 1.11a), which slope slightly downwards towards the south. It was coated with layers of clay, which have turned red due to the heat and had openings at three or four points at the top, to allow the glassworkers to pour in the batch of sand and soda.

Fig. 1.6: View from the east of the trenches made in the last furnace of sector 2; in the foreground, the trench into the tank which reached the floor associated with the initial glass-making activity, in the background, the trench dug into the external part of the west wall and the platform to observe the succession of the foundation and dismantling trenches. MAWN, A. Louis, 2008.

Fig. 1.7: View from the south of sector 1: on the left the western furnace, on the right the eastern furnace, partially excavated. Of the western furnace, two levels of the clean zone can be seen in the foreground, the upper one in stones, the lower one in square bricks, as well as the approach ramp; behind is the western wall of the tank and the preserved part of its northern wall; in the background, the enclosure of the firing-chamber. MAWN, L. Robin, 2008.

The tank was buried, probably up to the top of the vault, on two of its sides. The tank of the western furnace of sector 1, in each of its three phases, was buried on its eastern and western sides, the clean zone being situated on the rear side; there, three levels of pavement have been unearthed, the first two in reused square bricks, the last one in stone slabs (see Fig. 1.7). The eastern furnace of sector 1 was buried on its western and southern sides, the clean zone being located probably on the eastern side. In sector 2, the earliest tank was buried on its southern and western sides, the clean paved zone being on the eastern side; the next three furnaces were buried in the opposite way, the clean zone being situated on the western side (Fig. 1.12). Support walls were built to prevent the fills around the tanks spilling down into the clean areas. Access to the vaults during firing was provided by a platform from the clean zones, and perhaps also from the tops of the fills.

Fig. 1.8: View from the south of sector 1: on the left the western furnace, on the right the eastern furnace, partially excavated, showing the back wall of the furnace and part of the tank. The firing-chamber is situated under the thick salty petrified layer. MAWN, L. Robin, 2008.

Fig. 1.9: View from the east of the northern part of the tanks of the two parallel furnaces of sector 1: in the foreground, the blue green damaged floor of the eastern furnace, its western dismantled wall with the remains of its orange clay coating; in the background, the tank of the western furnace, with its western wall showing the traces of the different phases of activity. MAWN, V. Pichot, 2008.

Fig. 1.10: View from the North-East of sector 1: in the foreground, part of the enclosure in which the firing-chamber was located, in the background, the tank of the western furnace with the collapse of the vault (third level of study); the eastern furnace has not yet been excavated. MAWN, V. Pichot, 2006.

The firing-chamber is hard to reconstruct, due to the paucity of remains. What appears from the sector 1 western furnace excavation is that it had a square form (internal dimensions 2m × 2m) and was divided inside into five compartments (Fig. 1.13). The form of the opening between the firing chamber and the tank can only be guessed, as the levels preserved in sector 2 are too low and in sector 1, this crucial area was disturbed by the reoccupation of the zone. Basing our interpretation on the example of the Indian primary glass furnace at Jalesar (Sode and Kock 2001) and on the furnace of Kapadvanj, Gujarat (Kock and Sode 2002), we suggest that there was an opening across the whole width of the tank, to ensure an equal distribution of the heat, but we have no evidence for it. The compartment near to the tank (internal dimensions 2m × 1m) was 0.40m lower than the opening into the tank; the compartment further from the tank was lower than the former and divided into two parallel compartments, themselves divided in two unequal parts, principal and auxiliary, probably due to the need to process the ashes.

The firing-chamber seems to have been set in a partially buried enclosure (western furnace of sector 1), defined by support walls with an opening in the northern wall to bring in the fuel during the first two phases of activity of the furnace (Fig. 1.14).

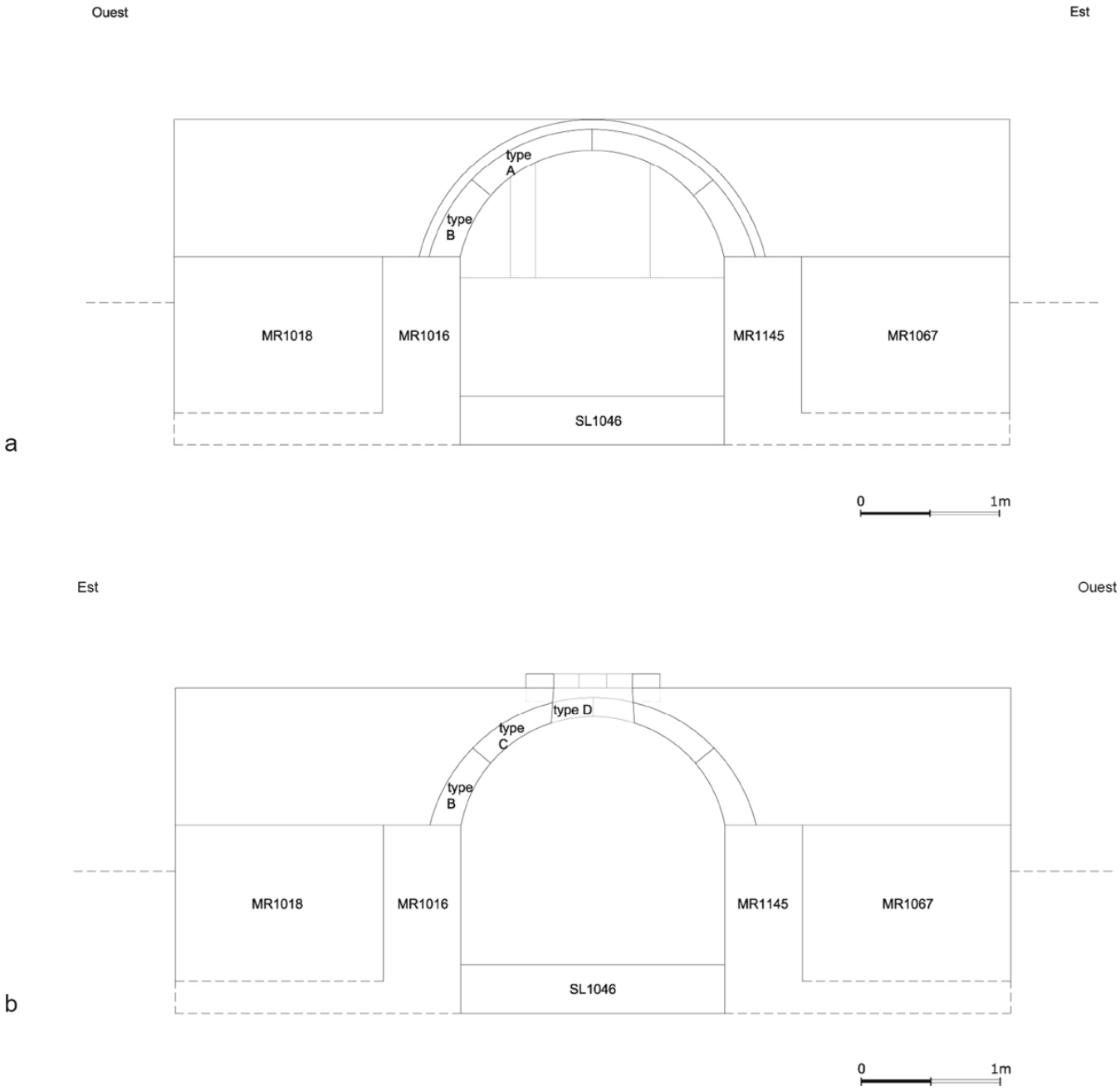

Fig. 1.11: (a) Reconstruction of the barrel vault of the western furnace of sector 1: section on a regular row looking to the north. MAWN, J. Badr, 2012. (b) Reconstruction of the barrel vault of the western furnace of sector 1: section on a row with a pouring/heat controlling hole, looking to the south. MAWN, J. Badr, 2012.

The location of the structures which would draw air through the furnace remains puzzling. At first, we believed that the chimney would stand on the top of the back wall, strengthened for this purpose in the same way as proposed in the reconstruction of the furnace of Bet Shearim (Brill 1967). But no traces of such a structure were found on the back walls of the three furnaces, and the location, in the case of the western furnace of sector 1, of the clean zone directly south of the back wall seems an obstacle to such an hypothesis. We wonder if

the heat was not simply accumulated in the tank, and some small openings were located inside the vault, which were used for pouring in the mixture of sand and soda, as well as for the control of the heat. This is the system which is used in the Jalesar furnace but that is a circular structure (Sode and Kock 2001). It is also suggested at Tyre, where there is excavation evidence for loading platforms at the rear of the furnaces (Aldsworth *et al*. 2002, 63).

Fig. 1.12: View from the south-west of sector 2: in the foreground, the support wall holding back the fills at the south of the tank, the clean zone paved with square bricks, and to the left of it the platform; in the background the tank. MAWN, A. Louis, 2008.

Building materials

The various dumps of bricks, including the collapse of the vault of the western furnace of sector 1, as well as the study of the existing walls and pavements have shown that three main types of bricks were used in the building of the furnaces and that very frequently the glassworkers reused bricks derived from earlier furnaces. Clay sources are available in Wadi Natrun and are still exploited today, for example near Zakik. The mud bricks, when strongly heated, present a gradation of colours going from green to yellow to red; when the bricks show this gradation of colours, but are not found in a position which would allow this progressive transformation of the colour of the clay, the bricks are considered to be reused.

Square bricks are found in two size categories: a small one of 0.20m × 0.20m × 0.10m and a larger one of 0.24m × 0.24m × 0.12m. They were used in some parts of the walls of the tank (in this case, the surface facing the interior of the tank has an irregular layer of blue-

green vitreous material, the colour of the other faces reflects the penetration of the heat), as well as probably to pave its floor (in that case, the upper surface is covered with vitreous material showing fractures where the glass was removed, and the sides are covered with a smooth blue-green vitreous layer). These square bricks were also re-used to pave the clean areas outside.

Large rectangular bricks, some of them with an oblique reverse side (length 0.48m, width 0.28m, thickness 0.16m) are employed in the walls of the tanks (Fig. 1.15). They can be clearly distinguished where the walls of the tank have not been modified due to the breaking up of the glass slab (Fig. 1.16). This matt vitreous layer, quite different from the shiny and smooth one formed on the curved bricks, was left by the glassworkers as it was unsuitable for remelting due to contamination by the clay of the bricks. Blue-green impure glass chunks are found everywhere, contaminated by the furnace walls, in the excavations and on the surface of the hill.

Four types of curved bricks of the same width (0.13m) are used in the vault: each regular row (Fig. 1.11a) comprises one brick on each side of even thickness (type B: length 0.50–60 m; thickness 0.18 m) and two elongated bricks in the centre (Fig. 1.17a–b; type A: length up to 0.70m; thickness from 0.18m to 0.11m). Fragments of curved bricks (type D) show a continuous regular vitreous layer on one of the joints, which has allowed us to suggest the presence of pouring/heat controlling vents at the top of the vault. In this kind of row (Fig. 1.11b), another type (C) of curved brick is used in addition to type B and D bricks. The lower or internal surface always bears an irregular shiny and smooth layer of blue-green vitreous material and the upper surface is always covered by a powdery red clay. The surfaces of the joints between the bricks show different colours going from green to yellow and red, reflecting the penetration of heat; a vitreous layer often penetrates into the joints.

Fig. 1.13: The firing-chamber of the western furnace of sector 1 (first phase of activity) from the north: at the top, the tank, then a rectangular compartment partially disturbed by the reoccupation phase (only half was excavated at the time when the photograph was taken), then another rectangular compartment divided horizontally in two by a row of bricks and vertically by a wall. MAWN, V. Pichot, 2009.

Fig. 1.14: View of the western furnace of sector 1 from the south: in the foreground, the tank, in the background the enclosure in which is set the firing-chamber (not visible on the photograph), with the support walls and the opening which was closed in the last phase of glassmaking activity. MAWN, M.-D. Nenna, 2009.

Fig. 1.15: Detail of the eastern wall of the eastern furnace of sector 1. At the base can be seen a single course of square bricks forming the levelling course of the wall and giving the level of the floor, and then the courses of big rectangular bricks. MAWN, V. Pichot, 2007.

Fig. 1.16: Detail of the internal face of the south wall of the main tank of sector 2 showing the courses of bricks and traces of breaking up the glass. MAWN, V. Merle, 2005.

Fig. 1.17: (a) Curved brick (type A) from the vault of the tank: face towards the inside of the tank. MAWN. (b) Curved brick from the vault of the tank: joint face. M.-D. Nenna.

To these main brick types should be added flat rectangular bricks (0.50m × 0.22–0.24m × 0.10m) used, for instance, in the paving of the firing-chamber, flat square bricks (0.20m × 0.20m × 0.65m), and small rectangular bricks. Clay was also used to cover the vault probably to quite a considerable thickness, and was subsequently reused (red clay) to form the external part of the wall which was to be dismantled in the next phase of activity.

The glass produced and the capacity of the furnaces

We cannot ascertain what type of glass was produced in each of the furnaces. All that we know from the scanty raw glass fragments found during the survey or during the excavation in the filling layers (which may not be connected directly to these furnaces) is that three different kinds of glass were produced in Beni Salama: blue green glass, colourless glass decolorized by antimony (Nenna *et al*. 2005, fig. 4; Picon *et al*. 2008: group wnc) and colourless glass decolourized by manganese.

Fig. 1.18: View from the sand plateau south of the industrial quarter (which is to the right) on the lake al-Fasidah (Egyptian Survey authority 1/50.000, 1997 (NU36-I1d)). MAWN, V.Pichot, 2003.

The capacity of the last tank of sector 2, if we apply a calculation similar to that applied to the furnaces at Tyre limiting the height of the glass slab to 0.65m (Aldsworth *et al*. 2002, 66), would be 22 tonnes of raw glass (length 7m × width 2m × thickness 0.65m × density of glass 2.5g/cm^3); if we limit the thickness of the slab to the thickness of the slab of Bet Shearim and to what can be inferred from the thickness of the glass blocks found in the Embiez Shipwreck, *i.e*. 0.45m, we come to roughly 15.75 tonnes. The capacity of the western furnace of sector 1 would be between 13 and 20 tonnes. However, the vitreous material left on the walls, contaminated by the clay from the bricks, should be subtracted from these results.

Loading and firing the furnaces

Sand and soda are available in the near vicinity of the site (Fig. 1.18). The plateau to the south of the industrial hills is composed of sand, and lake al-Fasidah (Egyptian Survey authority 1/50.000, 1997 [NU36-I1d]), also called Fazda in the literature (Shortland *et al*.

2006), is no more than 50 meters from the hills. Where and how the natron/trona was exploited can be inferred from a description in the *Description de l'Égypte* by General Andréossi (1809, 284), following a visit to Wadi Natrun in January 1799: 'Les hommes entrent nus dans l'eau, brisent et arrachent le natroun avec une pince de fer ronde, du poids d'environ soixante livres, formée à un des bouts en champignon et terminée de l'autre par une pointe acérée; ils ne font aucune attention à celui qui est à la surface du terrain, et qu'on pourrait enlever avec beaucoup moins de peine'. On the same page, Andréossi reports how the natron could be separated from the salt: 'Monsieur Regnault s'occupe d'un objet bien essentiel, celui de séparer en grand la soude contenue dans le natroun, afin de l'offrir au commerce dans son plus grand état de pureté (…). Dans quelques espèces de natroun, le sel marin se trouve compris entre deux couches horizontales de soude, en sorte que le premier pourroit être en quelque sorte détaché par une operation mécanique'. This operation of separation between salt and soda could be attested in the excavation by the curious find (Fig. 1.19), south of the western furnace of sector 1, of a huge dump of blocks of salt (see also the proposals of Shortland *et* al. 2011).

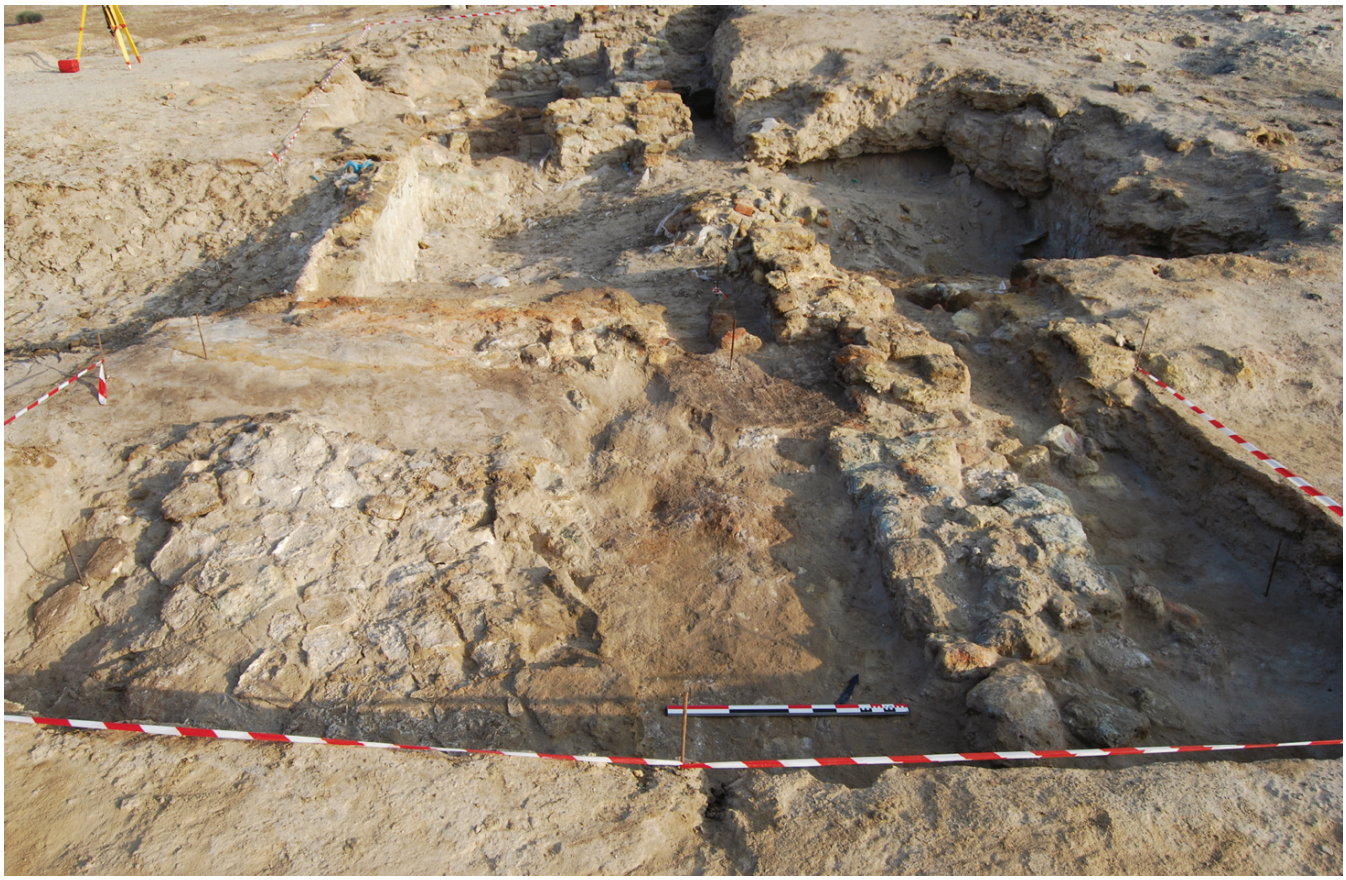

Fig. 1.19: View from the south of sector 1: on left the western furnace, on the right the eastern furnace, partially excavated. In the foreground can be seen the rubbish dump of salt blocks belonging probably to the phase of reoccupation of the sector. MAWN, L. Robin, 2008.

The amount of raw materials needed for one melt is not easy to calculate. For the furnaces of Bet Eli'ezer, the following calculation has been kindly provided by Ian Freestone: 'The extra weight over 8 tons should be from carbon dioxide and water, plus alkali, sulphates and chlorides which separate off as a scum. For a glass with about 20% Na_2O and 7% CaO, the amount of CO_2 and water lost will be about 35% of the weight of the glass, so a batch for 8

tonnes of glass would have been about 10.8 tonnes. The uncertainties are that this assumes that the natron used was pure trona. It will also have contained sulphate and chlorides, which would have added more weight (they will have separated off as a scum when the glass was melted). So the weight of the batch might have been more than this, maybe 12 tonnes? It is very difficult to be sure' (pers. comm. May 2008). If we apply a similar calculation to the furnaces of Beni Salama, it suggests that the glassworkers would have gathered a batch of sand and soda weighing between 17 and 31 tonnes. It would not have been possible to melt such a quantity, if all was placed in the tank at the same time so, as in the case of the Jalesar furnace, we suggest that the filling of the tank was progressive and extended throughout the long period of firing; this procedure would also account for the analytical differences which have been noted in the case of the Bet Eli'ezer glass (Freestone *et al*. 2000, 71). The glassworkers would have needed a clean zone to grind the mixture of sand and soda, which is why we inferred that the paved zones located near the tanks could be used for such a purpose. We do not have any clue about the tools used for this operation, except for a sieve, and different baskets found in the rubbish dump of sector 2. The loading of the furnace could have been made through openings in the vault; to approach the openings, platforms and ramps had to be built in the clean zone and that is how we interpret the foundations built on the paved zones south of the western furnace of sector 1 (see Fig. 1.7) and west of the furnace of sector 2 (see Fig. 1.5).

The question of the fuel needs to be addressed. Wadi Natrun was in antiquity in the Sahara desert and the vegetation was concentrated around the lakes and the wells. The most abundant fuel available was probably reeds which have a high calorific power and grow quickly (Fig. 1.18), and also tamarisk and palm-trees (for a review of the plants near the lakes at the end of the 18th century, see Andréossi 1809, 285, and thirty years later Wilkinson 1843, 116). Paleobotanical studies are in progress on wood and ashy earth found in the firing-chambers of sector 1 and 2. Reeds were essential in Graeco-Roman Egypt for heating, as we know from textual sources dealing with baths (Meyer 1987) and archaeological sources (Redon 2012). The Imperial edict of Caracalla (P *Giss* 40, col. 2) orders the expulsion from Alexandria of all the 'Egyptians', except the pork dealers, the inland waterway boatmen and 'those who bring the reeds for the heating of the baths'. Such light fuel is attested in the Jalesar furnaces, stalks of mustard plants producing large flames (Sode and Kock 2001, 163–164, figs 12–13).

The question of the duration of the firing has also to be considered. The only evidence that we have at our disposal is from ethnographic studies. In Nigeria, in the Nupe territory (Nadel 1940, 86), a small glassmaking furnace is reported (Diam. 0.60m; height 1.50m; estimated volume of glass produced 10–20 litres). The furnace is first lit for 6–7 hours with the batch inside, then 'a little slag from a blacksmith's forge is added and washed down by considerable quantities of water [note: the glass produced was black and the slag is rich in iron oxide, so may be added as a colorant]. After 18 hours the glass in the furnace has become liquid (…). After another 8 hours, the glass, now said to be finished, is taken out and left at the kiln side to cool'. In Jalesar, in a much bigger furnace (about 3 tonnes of batch), the melting of the batch is run without interruption for 30 days, and replenished with batch every third day. At the end of firing, the furnace is left to cool for about two weeks (Sode and Kock 2001, 165). So we must suppose that the duration of firing in Beni Salama was certainly very long and continuous, 30 days or more, with an additional cooling period. All in all, taking into account the manufacture of the building materials, the building of the furnace, the preparation of the raw materials and of the fuel, the firing and the cooling, the dismantling of part of the vault and of one of the long walls to get to the glass slab, the whole process could well have taken

several months and one must wonder if glassmaking was not seasonal. Andréossi was in Wadi Natrun in January and writes that the exploitation and the transport of the natrun towards Terenouthis took place only 'dans l'intervalle des semailles à la récolte', which in Egypt means between mid-November and mid-March. Such seasonality may also have been practised for glassmaking. It is noteworthy that we have not found any traces of domestic solid structures during the survey around Beni Salama, except for the occupation around the small fortress/temple on the plateau. The glassworkers might well have lived in ephemeral dwellings such as the one constructed in sector 1, in the firing-chamber and the northern two-thirds of the tank, after glass production had ceased but while the vault was still partly standing.

Once the glass slab was broken up, it was probably taken towards Terenouthis, on the Nile. In the 19th century the return journey to Wadi Natrun with a caravan of 150 camels and 500–660 donkeys, including breaking up of the natron and loading it, took 3 full days (Andréossi 1809); for Le Père (1812, 476) the distance between Tarranah/Terenouthis and Wadi Natrun is equivalent to 12 hours of walking (Wilkinson 1843, 113). The trade connections of the site generally appear to lie to the east, given that most of the amphora and domestic wares discovered during the excavations came from the east of Wadi Natrun, and fewer than 10% came from the Alexandrian and Mareotid workshops.

Comparison with Syro-Palestinian furnaces

The huge primary tank furnaces that we excavated in Beni Salama were something of a surprise, both in their date and their size. They are the earliest reverberatory furnaces of these dimensions known and their discovery raises a great number of questions about the quantity and the nature of the fuel, about the processes of preparing and loading the raw materials, about the duration of the firing and the maintenance of the temperature required for the melt (1100°C) of silica and soda, and about the cooling of the glass slab and its breaking up.

If we compare them to the Late Roman-Early Islamic furnaces of Bet Eli'ezer and Apollonia close to the Levantine coast, the first impression is that we are dealing with "experimental" furnaces rather than standardized furnaces. The tanks of the Beni Salama furnaces differ in their length (internal dimensions 7m and 6.1m) and differ greatly from the standardized length of the Levantine ones (4m), but they are not wider.

They are built with bricks of various forms and sizes; in Israel, a constant size of rectangular brick seems to have been used in Bet Eli'ezer (0.30m × 0.10m × 0.10m); in Apollonia ashlar blocks were combined with bricks of standardized size (0.30m × 0.15m × 0.10m). The walls of the Beni Salama tanks were much thicker, probably for three reasons: the quality of the fuel, the length of the tanks (and the assumed consequent difficulty in attaining and maintaining the high temperature) and their location, far away from each other. In the case of Bet Eli'ezer, the fact that the furnaces were set side by side in rows and were perhaps fired in groups allowed the glassworkers to reduce the thickness of the walls. The greater thickness of the rear wall in Beni Salama must also be connected to the problem of maintaining a high temperature.

We do not have any evidence for the thicknesses of the floors of the Bet Eli'ezer furnaces. In Beni Salama, their thickness, as well as the converging slopes of the vault and the ground towards the rear of the tank, served to store and maintain the heat.

The form of the vaults were also probably different, but the lack of available or published data on both Bet Eli'ezer and Apollonia building materials impedes any comparison.

The firing-chambers were certainly of a different form; square and unique in the case of Beni Salama with compartments to take away the ashes, triangular and double in the case of Bet Eli'ezer, rectangular and double in the case of Tyre. There were no remains at Beni Salama to determine the existence of supplementary firing-chambers on the long sides of the tank, as proposed by Brill for Bet Shearim. The difference in the nature of the fuel, wood in Israel and Lebanon, reeds at Wadi Natrun, could account for these differences.

The question of how air was drawn through the furnace remains: in the reconstruction of the Bet Eli'ezer furnaces (Gorin-Rosen 2000, figs 3–4), the chimney is placed at the end of the tank, but this may have resulted in incomplete melting of the batch situated under it; in the reconstruction of the Bet Shearim furnace (Brill 1967, 94), it is placed outside the tank. In Beni Salama, we have no archaeological traces for its location and wonder if it existed.

The four or five centuries which separate the Beni Salama furnaces from the Levantine ones, with no intervening evidence beyond the raw glass found in secondary glass workshops or shipwrecks, prevents us going any further with this comparative exercise. All we can stress is on the one hand the high degree of standardization of the Bet Eli'ezer and Apollonia furnaces in terms of the building materials, the details of the plan, and the systematic dismantling of the whole furnace, probably in order to reuse the building material and to be more efficient, while on the other hand at Beni Salama we have the heterogeneity of the building materials, the variations in plan and construction and the reuse of the same spot to build successive furnaces.

The duration of glass manufacture at Wadi Natrun

The time span of glass manufacture at Wadi Natrun is not easy to determine. The glass furnaces we excavated at Beni Salama are proof of the latest phase of glass activity, which does not extend beyond the end of the 2nd century AD. The evidence offered by the material found in the excavations (amphorae, pottery, vessel glass and faience) comes mainly from fills, and we have very few closed contexts, especially in sector 2. The chronological span of these objects goes from the end of the 2nd century BC to the end of the 2nd century AD. More precisely, we can infer from the study of the ceramics that were in the foundation layer of the western furnace of sector 1, we have elements dating to the 2nd century AD, and this is also true of the occupation layers connected to glass activities and to the reoccupation of this furnace.

This date, the early Roman period, is also attested at Bir Hooker and at Zakik, from what we can tell from the surveys and excavations. We have very few *testimonia* on the occupation of this region (*Sketis or Skitis*) in the Graeco-Roman period. Only a few textual sources (*BGU* II 648.7; Olympiodoros, *On Sacred Art*, 29) attest to the links between this region and Terenouthis on the Nile. More interestingly, a papyrus (P *Ryl*. II, 374, 4–5) dated to the 1st century AD, mentions in its first use (1st century BC), the glassworkers of *Schithis* (the difference in the spelling does not seem to be a problem for the papyrologists). We would thus have here a textual attestation of a glass industry in Wadi Natrun at the end of the Hellenistic period, but we do not have yet any clue to explain why the glass industry stopped at the end of the 2nd or – beginning of the 3rd century AD at the latest. Perhaps an explanation should be sought in climatic variation, as has been suggested for the shift from natron-based glass to plant-ash glass in the 9th century, as well as for the presence of plant-ash glass production in Wadi Natrun (Picon *et al*. 2008, 40–41). The fact that the three glassmaking sites stop their activity at the same time is consistent with this explanation.

Attributions of provenance of some groups of Early Islamic glass to the Wadi Natrun (Foy *et al*. 2003a, 141; Freestone 2005, appendix 1) should be dismissed, as no archaeological sites of this period, except for religious complexes of varying size, have been identified in the region (in addition to our work, see Innemée 2002). The glass slags mentioned in the preliminary reports of the Yale Monastic Project on the Monastery of Saint John the Little excavations (http://www.yale.edu/egyptology/ae_al-natrun_little.htm) are in fact slags connected to metallurgy.

When did this glass-making activity in Wadi Natrun begin? Were there earlier precursor furnaces in the region? At Bir Hooker we have identified evidence which indicates that raw glass was melted in a reverberatory type of furnace and has flow marks on the surface (Nenna *et al*. 2005, 60–61, Picon *et al*. 2008) and we know that the Sanguinaires A cargo of glass dated to the 3rd century BC contains chunks which bear the same traces of a flowing/melting process (Foy and Nenna 2001a, 102). These traces are proof, even if we cannot ascertain its form, of a different kind of furnace from those we excavated in Beni Salama and probably pre-dated them. The example of the glassworkers of the Nupe ethnic group in Nigeria, still producing primary glass in the 1930s, has not yet attracted the attention of the community of glass specialists (Nadel 1940), but it shows yet another type of primary glass kiln, built on the model of an iron-smelting furnace.

The next step is to wonder when the huge tank furnaces of reverberatory type could have appeared. There are some clues. One is the increase of raw glass production which must have accompanied the substantial increase in the abundance of glass tableware through the Eastern Mediterranean region at the end of the 2nd century BC. Another is the common and abundant character of Egyptian glassware, at the same level with the other two characteristic products of Egypt – linen and papyri – revealed in the *Pro Rabirio Postumo* speech of Cicero dated to 54 BC. Lastly there is the enigmatic *hyalinê puelos* of Alexander the Great, which replaced the gold sarcophagus which was stolen by Ptolemy X in 88 BC. Most of the commentators on this passage of Strabo (XVII, 8) translate these terms as 'alabaster sarcophagus', but why would Strabo, who knew about the glassworkers and their products, have used the term *glass* to designate alabaster? The term *puelos* is used in Greek literature for describing a cavity and from there a trough, a bath and a sarcophagus; in the papyri, it describes the flattish tubs which were built inside the characteristically Egyptian collective tholos baths. It seems most probable that between 88 BC and 27–20 BC, the date Strabo stayed in Alexandria, a true glass sarcophagus was made, and one of the ways it could have been made was to use one or more glass slabs to create the tub and the cover. These clues could be synchronous with a change in the architecture and the size of the primary furnaces and a shift to bigger furnaces during the 1st century BC, perhaps of the type that we have discovered.

The market for the Wadi Natrun glass

The glass which was produced in Wadi Natrun was of three main kinds: blue-green glass, colourless glass decolourized with manganese and colourless glass decolourized with antimony (Nenna *et al*. 2005, Picon *et al*. 2008, 37–38), of a limited production, with higher percentages of soda than the colourless glass known throughout the Roman Empire (Foy *et al*. 2004). The raw glasses from Wadi Natrun were probably mainly supplying the Egyptian market. To date, only glass vessels decolorized by antimony (wnc composition) found outside Egypt have been shown to have a similar composition to the different groups of glass produced in these three workshops (Cabart and Velde 2009; Picon *et al*. 2008). The general dearth of analytical data

for glass vessels found on Graeco-Roman consumption sites in Egypt limits our understanding of the secondary glass production centres using these raw glasses (Nenna 2013). The distribution centre for the raw glass was surely Terenouthis, but from there, raw glass could go potentially everywhere in Egypt, being transported on the Nile.

* * *

The Wadi Natrun glassmaking workshops are part of a long series of glassmaking centres which are thought, mainly on the basis of analytical data, to have been located in Egypt. However, they are the only ones which offer us wellpreserved and dated architectural structures. More research needs to be done to locate the different Graeco-Roman compositional groups that have been identified analytically. There are on the one hand the soda-lime-silica glasses such as the imperial colourless glass (the *vitrum alexandrinum* of the Edict of Diocletian) or the Late Roman HIMT group with high percentages of iron, manganese and titanium (Nenna 2014), and on the other the plant-ash soda glass such as the small groups of opaque glasses used in mosaic glass (Nenna and Gratuze 2009), or the bigger poorer quality blue-green glass group used in Egyptian utilitarian flasks of the first three centuries AD. Recently, the floor of a primary glass furnace was identified in a survey at Antinoopolis (Silvano in press); we are awaiting its date. Thus, Egypt presents, across the centuries (for later periods see Foy *et al*. 2003a) a wider variety of glass compositions than the Levant and it shows us that there were, in Egypt, different levels and degrees of raw glass production and trade: some very specialized and limited in quantity, such as the opaque glasses production centres, some which were supplying only the Egyptian market, such as the blue green plant ash glass for utilitarian wares, and some which were supplying Egyptian and international markets, such as the HIMT glass.

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2

THE HAMBACH GLASS PRODUCTION IN THE LATE ROMAN PERIOD

Anna-Barbara Follmann-Schulz

Introduction

Since 1975 open-cast mining of anthracite has required archaeological recording around the village of Hambach, which has since disappeared. Eight Late Roman glass factories have been discovered in this area, the so-called Hambach Forest, about 35km from the River Rhine and just south of the major Roman road connecting Cologne (*CCAA*) with Boulogne (*Bononia*) on the Channel coast, via Jülich (*Iuliacum*), Heerlen (*Coriovallum*) and Tongeren (*Atuatuca*). The sites are in an area of 25km^2 crossed by some secondary roads and pathways (Fig. 2.1); they are identified by codes HA 59, 75, 111, 127, 132, 382, 488 and 500. This paper is a summary of the more detailed publication of some of the sites by Gaitzsch *et al*. (2000); see also the short critical note by Nenna (2006, 118–119, no. 233). HA 127 and HA 488 were later discoveries, and in 2006 a new site with glass-working remains, Düren 'Im großen Tal', was discovered about 5km south-west of HA 500.

There had been agricultural activity in the region since the 1st century AD but in the 3rd century alterations to the climate and political instability caused economic changes. As a result glassmakers settled in the former *villae rusticae* during the 4th century. The cemetery associated with HA 132 has several inhumations, while those in HA 382 and HA 500 have only some Late Roman graves; all were furnished with numerous glass objects. The 4th-century date is based on the 47 coins in poor condition that had been hidden or lost in a furnace at HA 500 – they date to the mid-4th century (Zedelius 1980; Heege 1997, 36) – and on the ceramics from near the furnaces on the other Hambach sites, the types of crucibles and especially the grave goods, which date the glassworking to the period from the mid-4th to the second third of the 5th century (Brüggler 2009).

Glassworking

More than 40 glass furnaces were excavated. Three furnace shapes for different stages of the production process were distinguished, but their specific function is not always clear because intensive cultivation in later times means only the lowest layers of the Roman buildings are preserved.

A: circular – melting and blowing

Aa: pear-shaped – melting and blowing

B: semicircular with rectangular section – annealing

C: rectangular – tank-furnace for raw glass production (?)

Types A and Aa have been combined by Gaitzsch (Gaitzsch *et al*. 2000, 103) while Brüggler distinguishes them (Brüggler and Daskiewicz 2004, 806 note 12).

At two sites shelters were recorded (HA 111: Gaitzsch *et al*. 2000, 97–98, Abb 10; HA 132: Gaitzsch *et al*. 2000, 100, Abb 12). They were constructed of wooden posts on stone bases; three sides were closed, one open. They protected several adjacent working furnaces from the weather. For site HA 59 see Hallmann-Preuß (2002/2003, 389) and for HA 75 Rech (1982, 360–362).

Archaeobotanical analyses of carbonized wood determined the fuel: birch, oak, willow, ash, alder, hazel and fruit trees from sparsely-wooded forests which had extended into the region from the end of the 3rd century onwards (Tegtmeier in Gaitzsch *et al*. 2000, 148–153).

The crucibles were refractory ceramic bowls of Mayen fabric with quartz and volcanic inclusions; they belong to the Rhenish pottery type Niederbieber 104/Alzey 28, widemouthed with an inturned flange at the rim (Fig. 2.2). Other pots from HA 75 were greyish brown with quartz inclusions and had a broader rim with a sharply incised ridge (RLM Bonn Inv 75.1953; Fig. 2.3). Note the drawing by Rech (1982, 370, fig. 10, 1) is incorrect. Those from HA 127 were red-brown with white quartz and dark volcanic inclusions and had a flattened groove and half-rounded rib beneath (St. 133–8; Fig. 2.4). It seems that the rims of straighter-walled pots like that from HA 382 had been cut away when used for melting glass (Gaitzsch in Gaitzsch *et al*. 2000, 110). On the outer surface of the crucibles there is often the remains of an added clay layer.

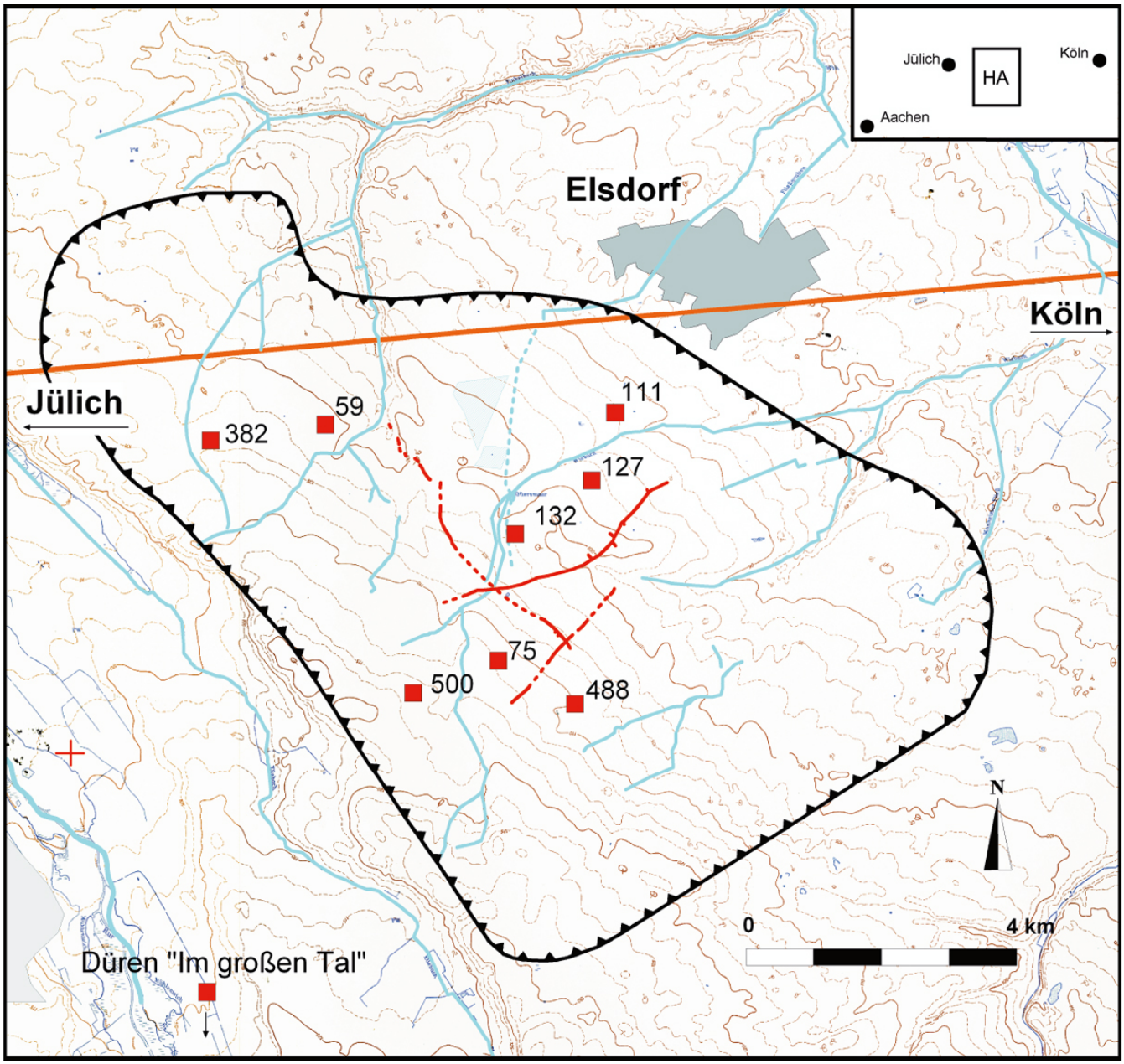


Fig. 2.1: Roman glass factories (squares) in the Hambach Forest south of the Roman road from Köln (Cologne) to Jülich, connected by secondary roads. The heavy line shows the area removed by the opencast coal mine (drawing by W. Gaitzsch and W. Warda).

The glass

The glass waste scattered around the furnaces contained moiles, threads, droplets, pieces of raw glass and vessel fragments. It seems unlikely that cullet was intentionally collected from other places so the vessel fragments may be classed as products. The glass grave-goods correspond partly to the shapes and types identified from the wasters. Chemical analyses should prove that both were produced locally. Samples of vessel fragments, raw glass, glass from the crucibles and waste have been analysed by X-ray fluorescence (Wedepohl and Hartmann in Gaitzsch *et al*. 2000, 131–147; Wedepohl *et al*. 2003, 56–61). With regard to the products, the Hambach glass factories will be treated here as a unit. Wedepohl (in Gaitzsch *et*

al. 2000, 136 and 153) pointed to the generally high iron level of the Hambach glass but he also noticed higher- and lower-iron glasses, which he assigned to different workplaces. The factories did not work independently; they exchanged their products. Compared with the average iron content of western European Roman glass the Hambach glass is a high-iron product (0.7–1.7% Fe_2O_3). The Hambach high-iron glass is characterized by the correlation of iron with titanium, vanadium and manganese contents. This correlation differs from products of other late Roman glass-producing sites, *e.g*. Goch-Asperden (Hinz and Hömberg 1968; Bridger 2004; Brüggler 2007) and Trier (Gaitzsch *et al*. 2000, 139, Tab 7, 145–56). The high strontium content indicates the use of seashells for the necessary lime-addition (Wedepohl and Baumann 2000). Heavy minerals and lead isotopes in the glass point to the fact that river-sands from the Rur (Roer) were used for raw glass production (Wedepohl and Baumann 2000; Gottschalk and Baumann 2001). The Rur passes less than 10km west of the Hambach region; it runs through the lead deposits of Mechernich-Maubach in the Eifel and carries along the heavy minerals. Thus, there was raw glass production in the Hambach glass factories using local river-sands; soda and seashells were imported from Egypt and from the Channel coast respectively.

The glass colour depends not only on the added minerals but also on the atmosphere in the furnaces. The Hambach glass varies from colourless/yellow-white (Munsell 5Y8.5/2) to green (10GY7/4) and green-yellow (5GY8.5/4). Applied threads and blobs are blue (2.5PB7/8) and yellow-brown (2.5Y5/6–4/4).

Mould-blown vessels

The products deduced from the wasters and analyses include mainly tableware: plates, bowls, beakers, cups, drinking horns, bottles and flasks (Fig. 2.5). Only the barrelshaped bottles were also suitable for transport and storage. A cylindrical bottle with dolphin handles (Isings 1957, form 100a; Goethert-Polaschek 1977 form 140) and a square bottle or jar of uncertain type could only be identified from waster fragments; all other types are also represented in the graves. Among the Hambach products are two mould-blown vessel types: barrel-shaped bottles with a base-mark and shallow bowls with cross-hatched lozenge ornaments.

The letters ECVA are recorded on a waster sherd (HA 111, St 11–6, sample Ham 74) and on the base of a nearly complete bottle from a grave (HA 132, St 188–08 sample Ham 36). Both stamps are identical in character; they came from the same mould (ECVA stamp A; Figs 2.6–2.7); the analysis confirmed they were Hambach products. Other barrel-shaped bottles with identical base-marks may be classed (most probably) as 'Hambachian' even without a chemical fingerprint. Bottles of the same shape excavated in Bonn (Bonn, RLM Bonn Inv 21737,05, sample Bon 2) and Cologne (RGM Cologne Inv 67, 1080, sample Köl 17; RLM Bonn Inv 8988, sample Köl 13) bearing another version of ECVA (stamp B; Fig. 2.8) were shown to be Hambach products by analysis. One can add to the list of ECVA stamp B another barrel-shaped bottle from Hürth-Hermülheim (RLM Bonn Inv 2005.274,04). (Bottles with ECVA-stamps variant C and D have not been analysed.)

The stamps of EQVALVPIOFEC (Fig. 2.9) are considered to be a Hambach product by the chemical fingerprint of items from Cologne (RLM Bonn Inv 7710, sample Köl 12) and Krefeld-Gellep (Museum Burg Linn Krefeld Inv 2905/4, sample Gel 28); so far the mark has been found on nine bottles, presumably from the same mould.

There is a special ligature of the name FRON(tinus) on a basal fragment from HA 75 (RLM Bonn Inv 76.3084, sample Ham 105) and on a barrel-shaped bottle from a grave of HA 132

(St 184–11, sample Ham 119). A little semicircle is used instead of the two short horizontal bars of the character F (Figs 2.10–2.11).

Chemical analyses and identical design elements characterize the shallow bowls with cross-hatched lozenges as Hambach products (Ha 132 St 182–13, sample Ham 63; Eschweiler-Lohn, RLM Bonn Inv 79.1944,09, sample Esc 1; Figs 2.12–2.13). A little depression in one of the angles of the middle cross-bars is caused by a defect in the mould. It is an additional indication that the bowls are of the same pattern.

Distribution of Hambach glass products

The market area of identical mould-blown vessel glass is relatively easy to investigate, providing there are enough specimens. The ECVA-stamp versions A and B spread around the glass factories and along the Rhine from Krefeld-Gellep in the north to Wolfsheim near Mainz in the south (Fig. 2.14). The EQVALVPIOFEC marks are known from Cologne, Krefeld-Gellep and further north, from Bedburg-Hau near Kleve (Fig. 2.14). The find-spots of FRON with the semicircle instead of the horizontal bars have not been investigated in detail; the stamp occurs in Cologne (RGM Cologne Inv 67,852 and 67,1242) and Krefeld-Gellep (Museum Burg Linn Krefeld Inv 1276/3 and 2658/4 (Pirling 1974, 11 no 1276,3 Taf 9,2; Pirling 1979, 58 no 2658,4 Taf. 57,1; cf. Pirling and Siepen 2006, 291–2 form Gellep 213)) in addition to the Hambach area. The bowls with cross-hatched lozenges have a similar distribution (Fig. 2.15); they were offerings in two graves at the glass-working site HA 132, in two graves of Eschweiler-Lohn (WW 39; graves 29 and 24, RLM Bonn Inv 79.1944,09 and Inv 79.1939,03), in a grave at the Late Roman cemetery of Altinden (Inden-Altinden WW 2004/61, St 609–07 (08), RLM Bonn Eing Nr 2005/3) and in sarcophagus 2 at Cologne-Braunsfeld (RGM Köln Inv 997). The most southern findspot is Remagen, where a fragment was discovered in the late Roman fill of a cellar (Sibylle Friedrich recognized the fragment, RLM Bonn Inv 28978(38); Fig. 2.16 (Friedrich 2010, 231 Nr. 10; Taf. 75,10). The Cologne-Braunsfeld bowl (Schulze 1980, 123 no 157, fig. 157, Schulze 1981, 123, no 168, fig 78) had been ascribed to a group of mould-blown bowls, mostly discovered in northeastern France. Their production is assumed to have been between the Seine and the Maas. Many of these bowls bear Christian symbols on the bottom. The bowls with lozenges that are Hambach products must now be separated; they form an independent group. However, they may be the last pagan forerunners of the Christian ones.

Fig. 2.2: Crucible of Niederbieber 104 A hey 28 type from HA 500 with a thick glass layer inside and an added clay layer outside Minmoter 360mm) (photograph H. Lilienthal. drawing courtesy of Rheinisches Landesmuseum Bonn).

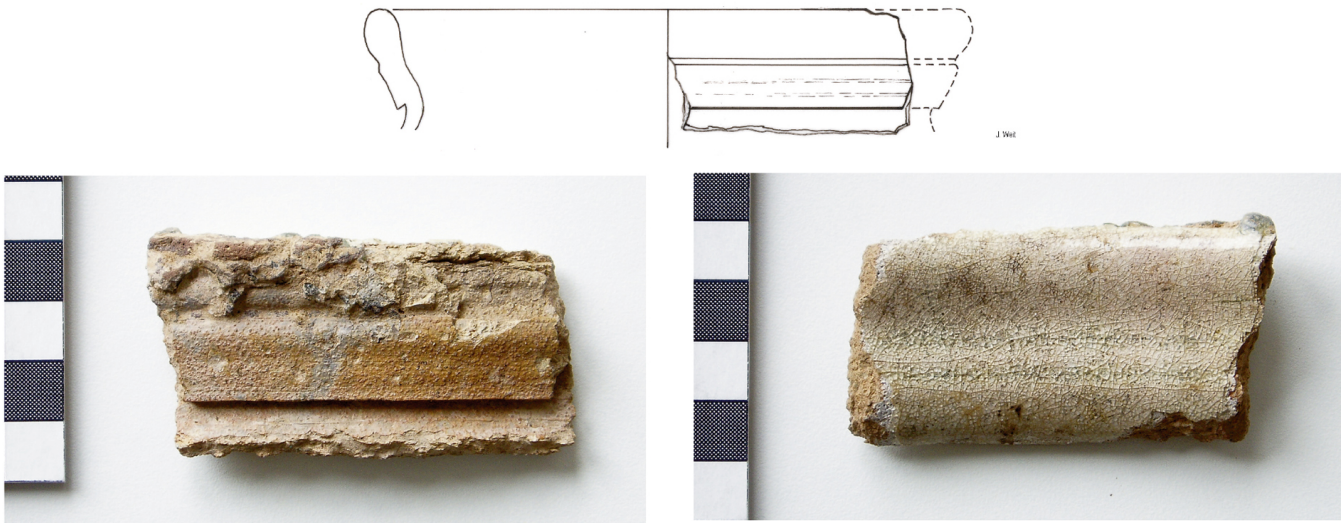


Fig. 2.3: Rim of crucible from HA 75 (diameter 180mm) (photograph A.-B. Follmann-Schulz, drawing by J. Weil).

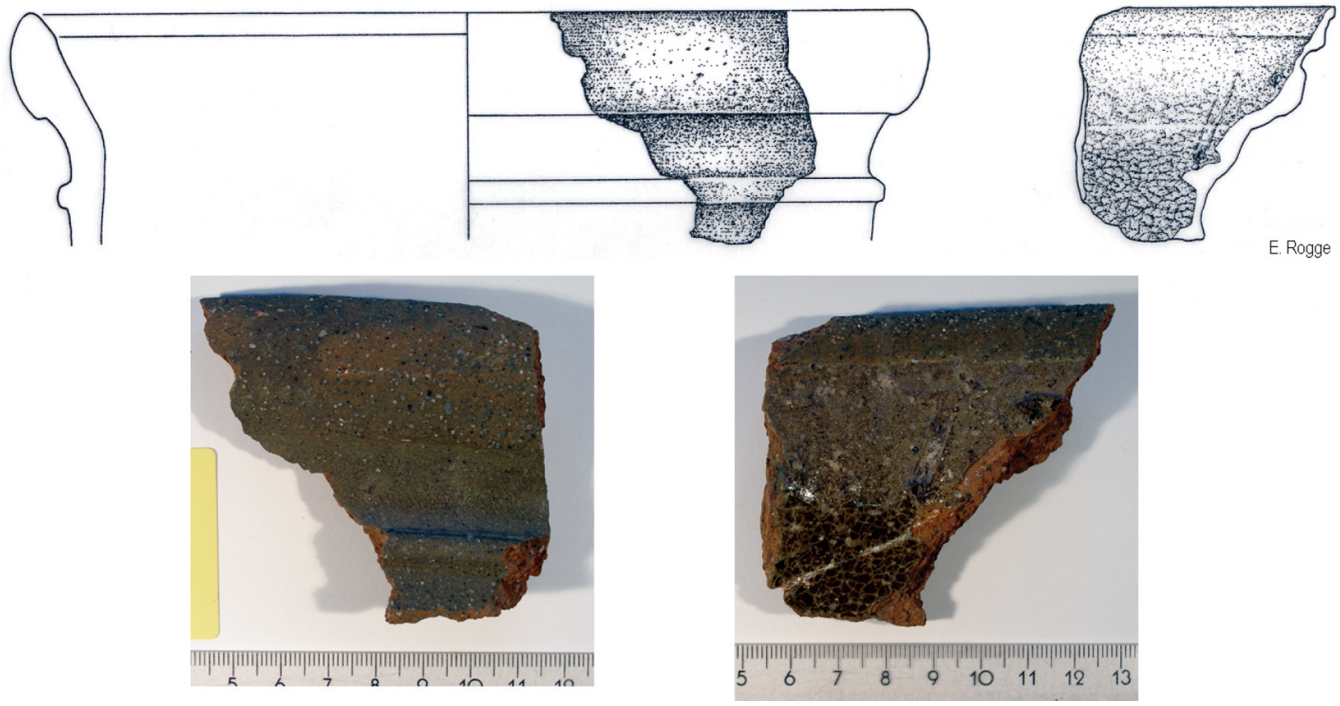
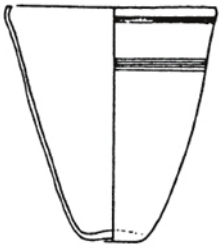
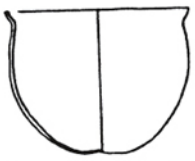


Fig. 2.4: Rim of crucible from HA 127 (diameter 240mm) (photograph A.-B. Follmann-Schulz, drawing by E. Rogge).

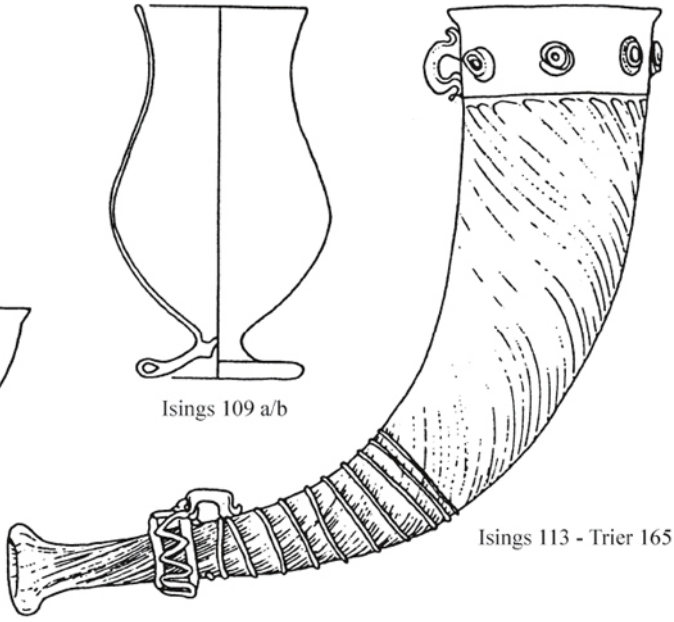


Isings 106a - Trier 53a



Isings 96a - Trier 49a

Isings 109 a/b



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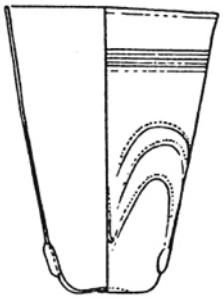
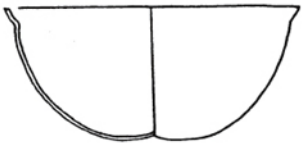


Isings 106 c2



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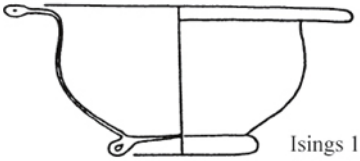

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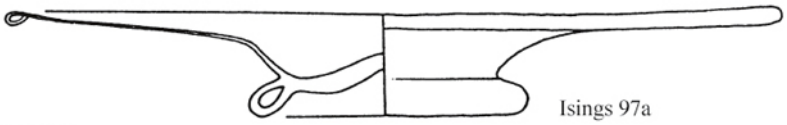
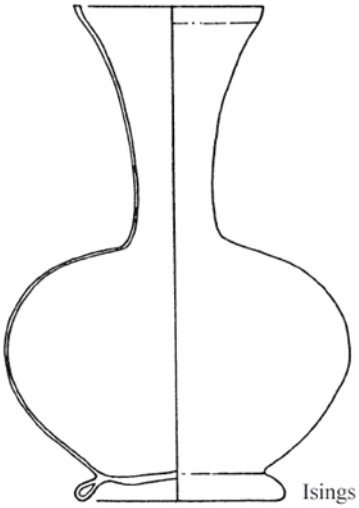


Isings 97a



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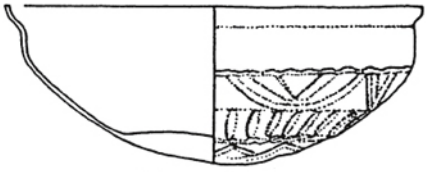
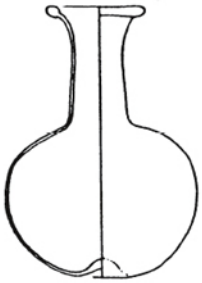
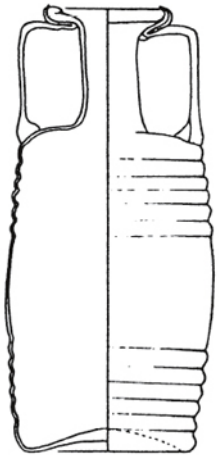


Isings 116 - Trier 15a



Isings 101 - Trier 79a

Isings 132 - Trier 111



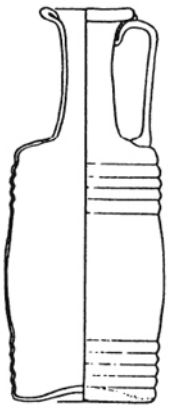
Isings 128 - Trier 142

HA 132 St. 188-08

HA 111 St. 11-06

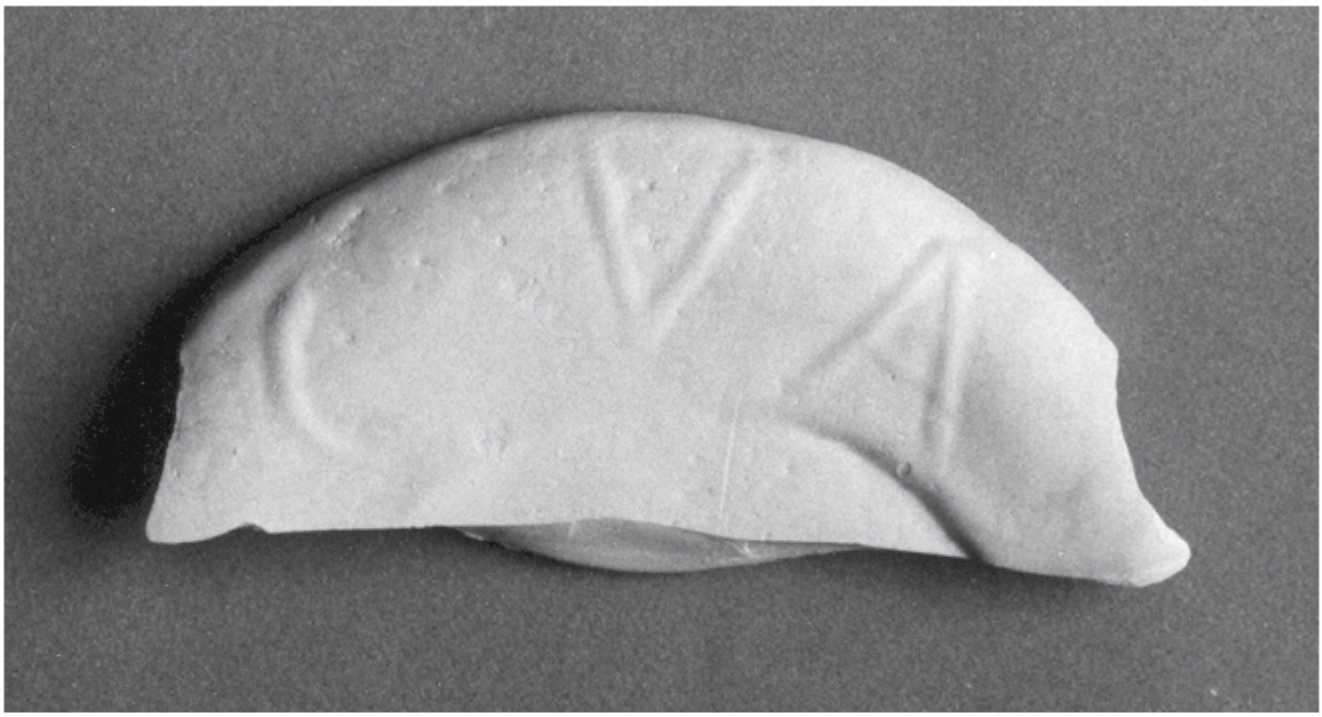
HA 132 St. 184-11

HA 75 Inv. 76.3084



Isings 89 - Trier 121

Fig. 2.5: Vessel types produced in the Hambach area (drawing by U. Naber).



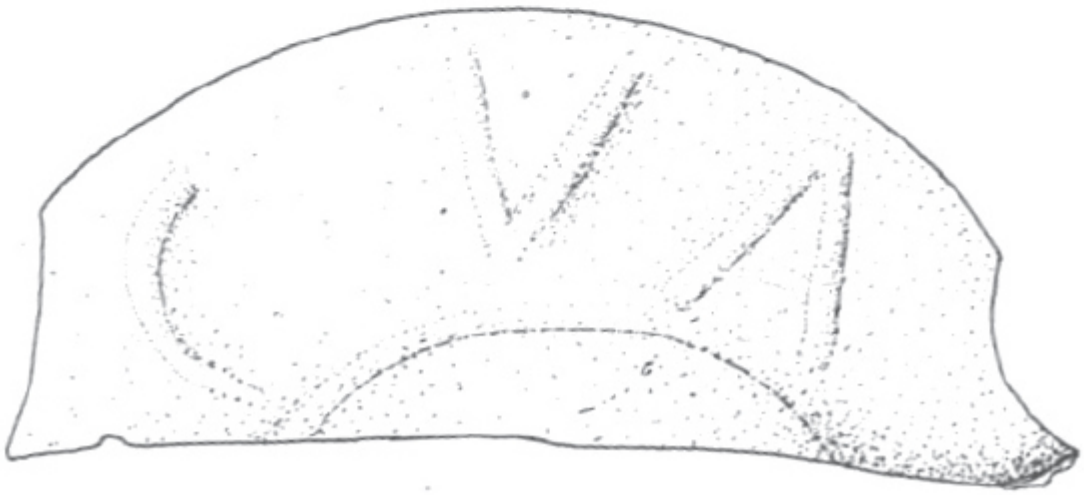


Fig. 2.6: Plaster cast and drawing of ECVA stamp A on a waster sherd from HA 111, St 11–06 (photograph S. Schröder, drawing by U. Naber).

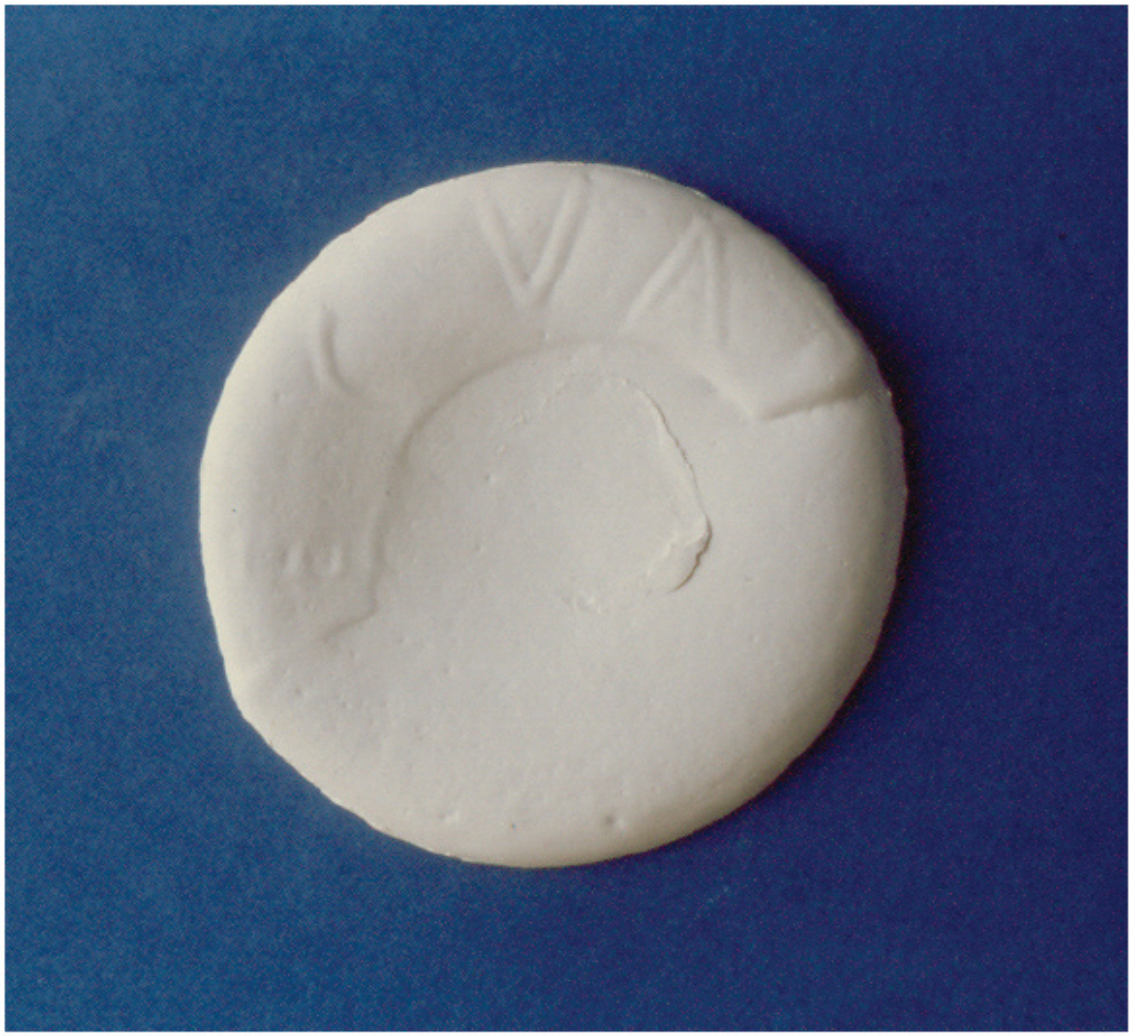
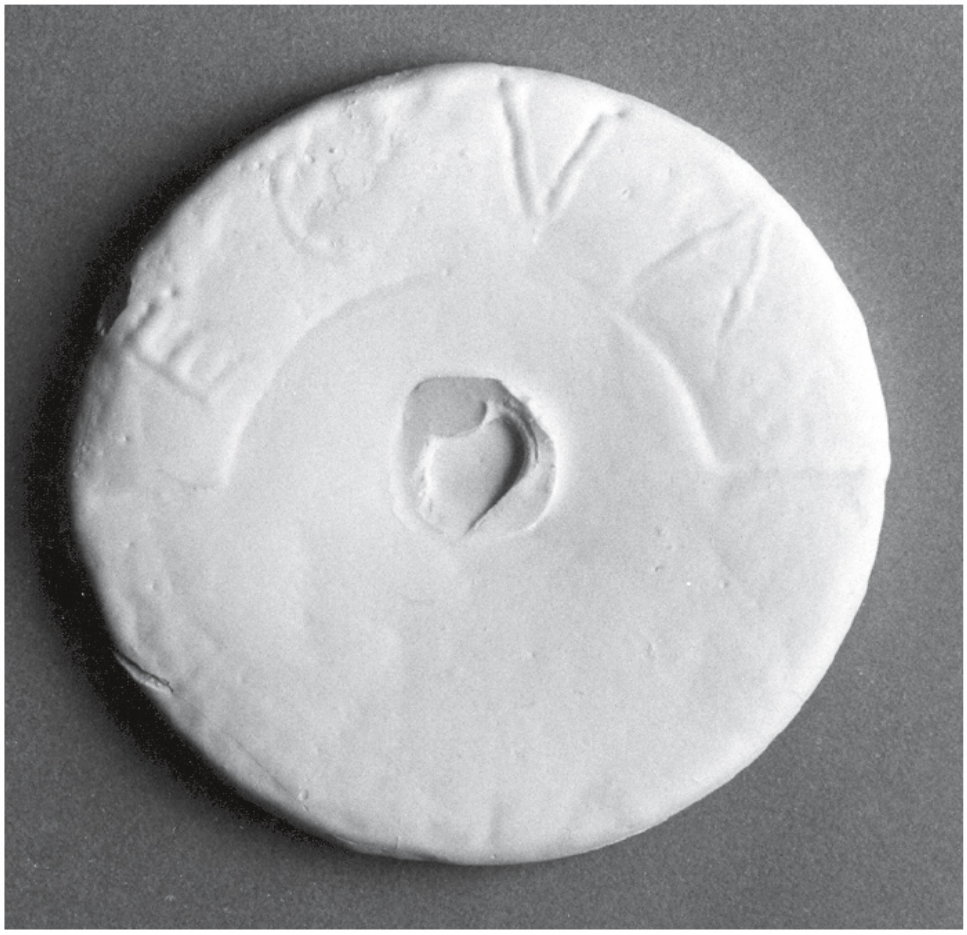


Fig. 2.7: Plaster cast and drawing of ECVA stamp A on the base of a bottle from HA 132, St 188–08 (photograph S. Schröder, drawing by E. Feuser).



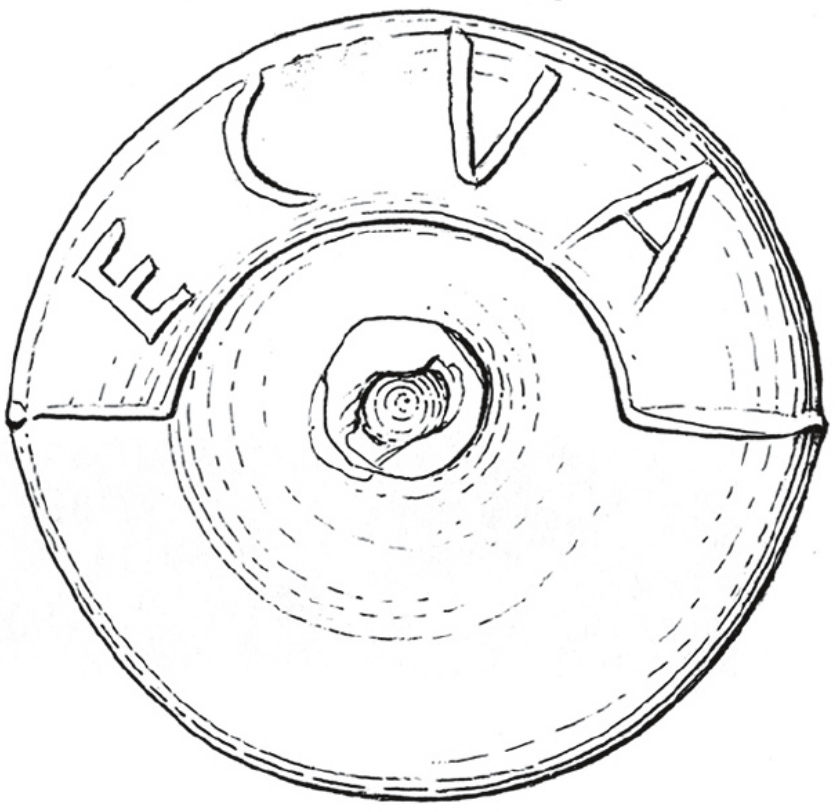
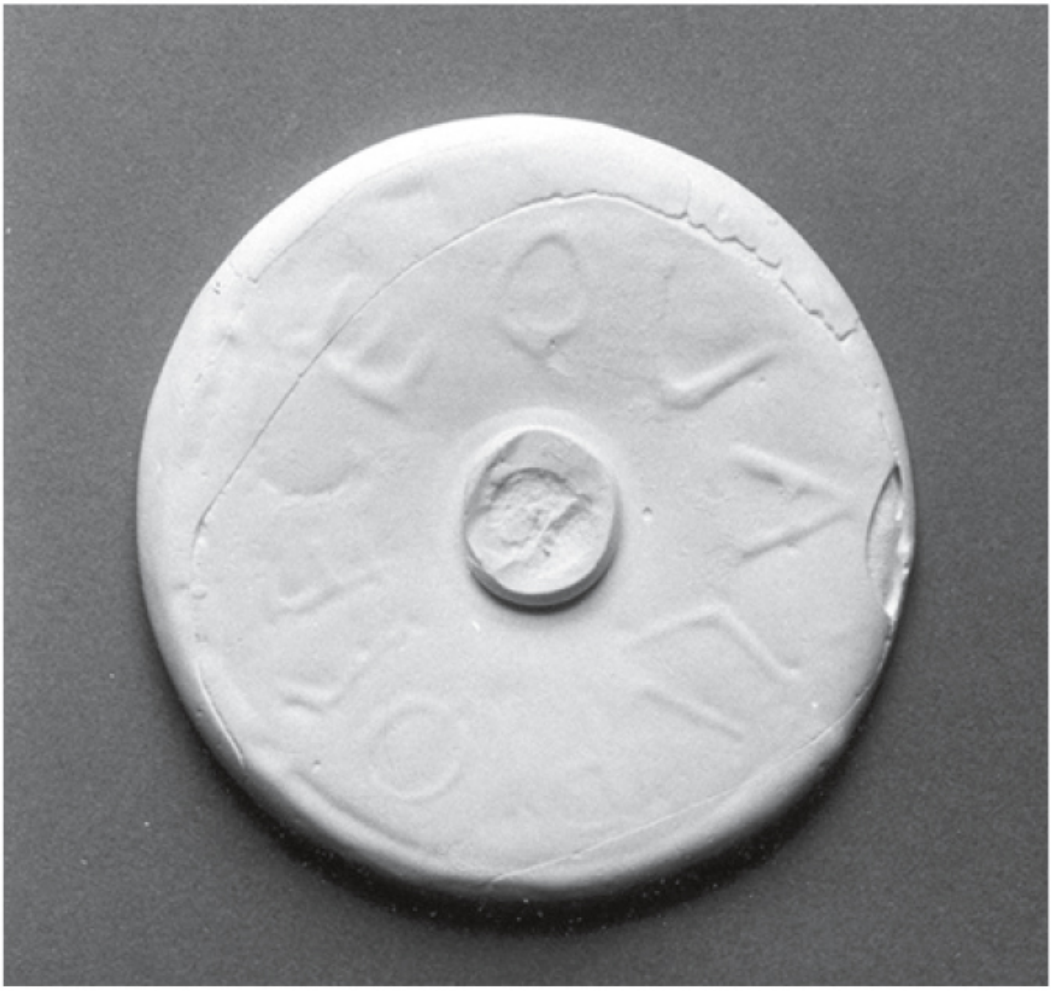


Fig. 2.8: Plaster cast and drawing of ECVA stamp B on the base of a bottle from Bonn, RLM Bonn Inv 21737,05 (photograph S. Schröder, drawing by U. Naber).



QVA
VRIAE

Fig. 2.9: Plaster cast and drawing of EOVÆIPIOFEC stamp on the base of a bottle from Cologne, RLÀI Bonn Inv 7710 (photograph S. Schröder, drawing by U. Naber).

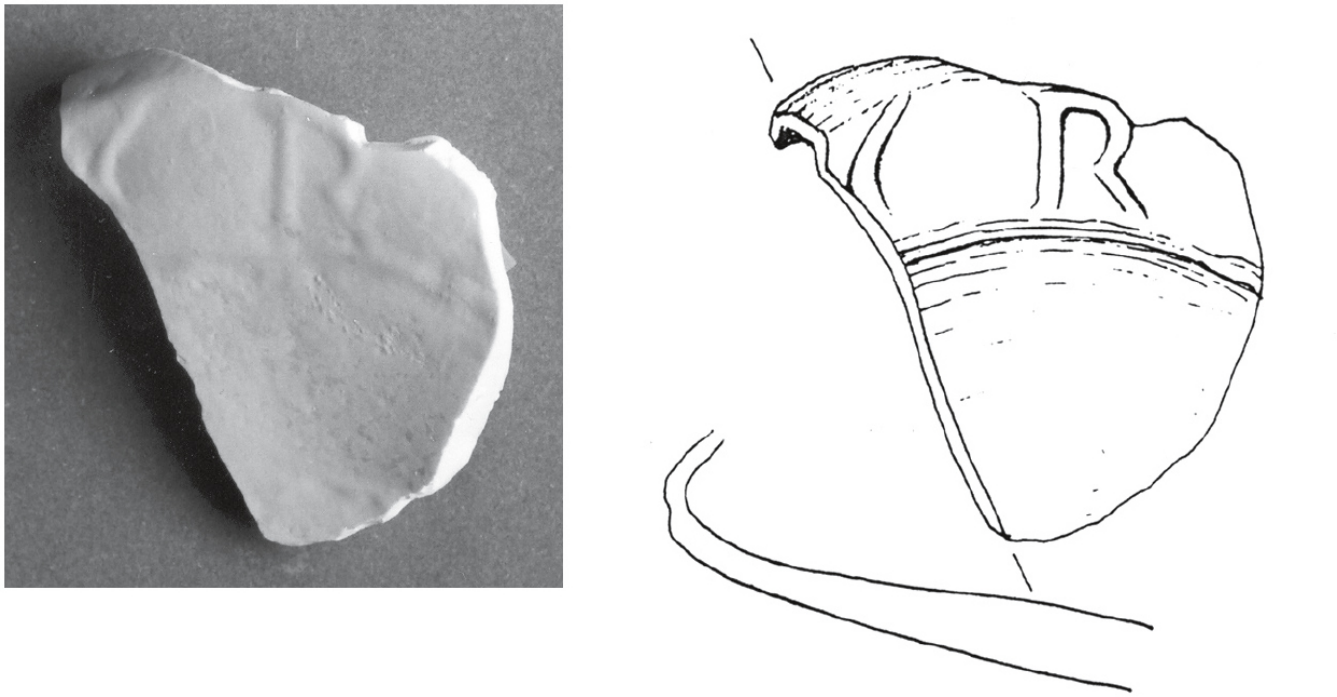
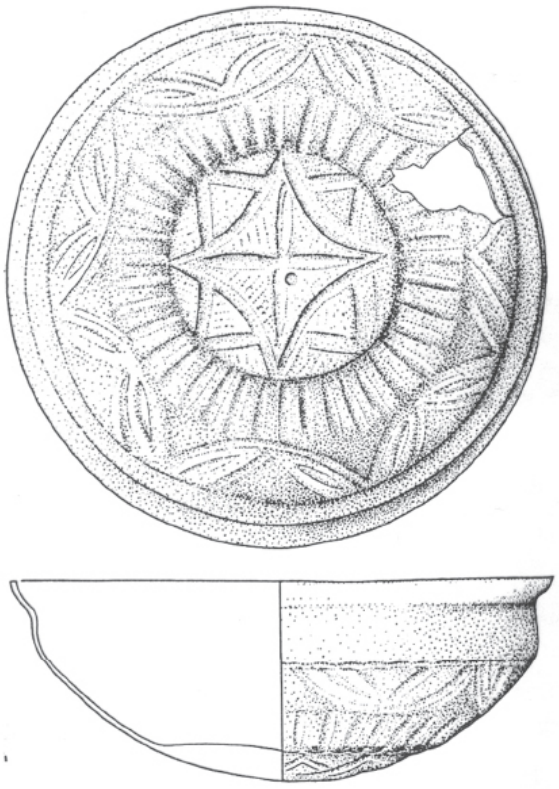


Fig. 2.10: Plaster cast and drawing of FRON stamp on a waster sherd from HA 75, RLM Bonn Inv 76.3084 (photograph S. Schröder, drawing by U. Naber).

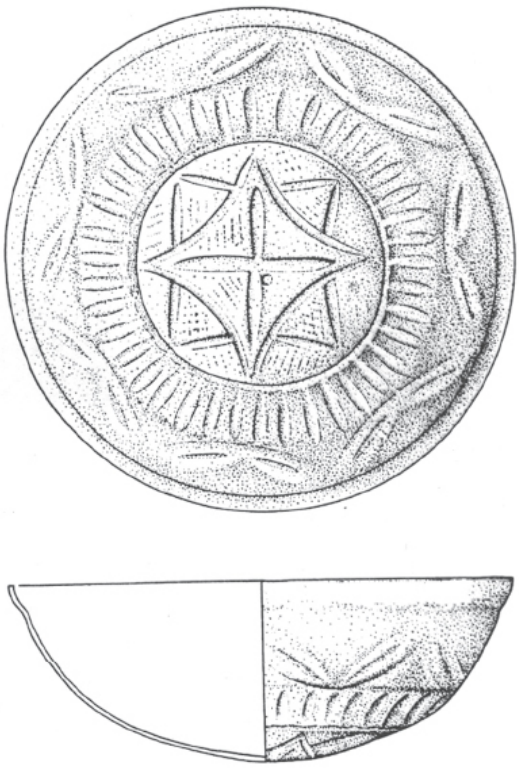
Fig. 2.11: Plaster cast and drawing of FRON stamp on the base of a bottle from HA 132, St 184–11 (photograph S. Schröder, drawing by U. Naber).

Postscript on the mould-blown bowls with lozenges

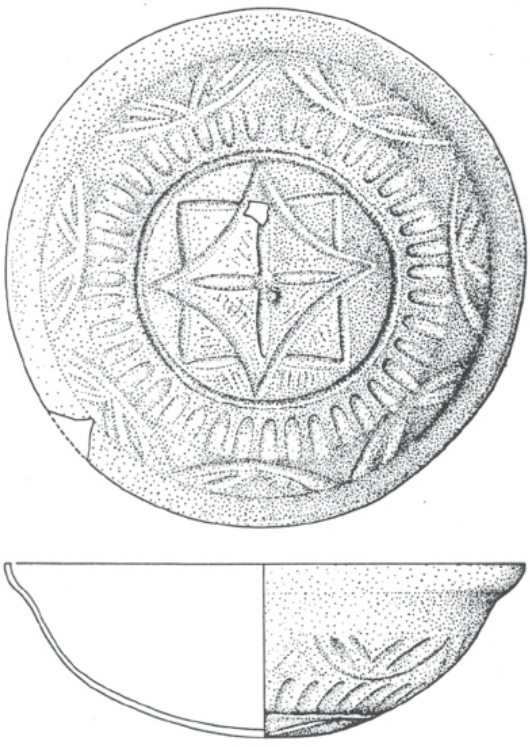
Since the appearance of the publication by Gaitzsch *et al*. (2000, 119) the number of identical bowls with crosshatched lozenges has increased: fragments in a second grave from Eschweiler-Lohn, the fragment from Remagen with the tell-tale little depression (Fig. 2.16) and the bowl from the grave at Altinden (Fig. 2.17); the latter is of special interest. The pattern on the bowls normally consists of the central lozenges, a circle of short perpendicular rods and a row of horizontal double leaves (Fig. 2.12). Looking at the Altinden bowl we can see the lozenges with the little depression in one of the angles of the crossbars, the zone with the rods, but then the decoration stops; the double leaves are missing. As there is no doubt that the decoration is identical to the other bowls, this irregularity can only be explained by a defect in the mould: the upper part had been used up and broken off. Thus, the Altinden bowl should be one of the last products coming from the presumed identical mould.



a) HA 132 St. 182-13



b) HA 132 St. 189-19



c) Eschweiler-Lohn

d) Köln-Braunsfeld

Fig. 2.12: Mould-blown bowls with cross-hatched lozenges from HA 132, Eschweiler-Lohn and Köln-Braunsfeld (drawings by E. Feuser and U. Naber), d) after Fremersdorf (1961, pl. 132).

Conclusion

The investigation of the Hambach glass houses by chemical and typological analyses established a definite production line. The spread of some mould-blown vessels could be traced. The factories worked for personal use both locally and in a wider area. The ECVA-stamped bottles had the furthest distribution, but still a regional one.

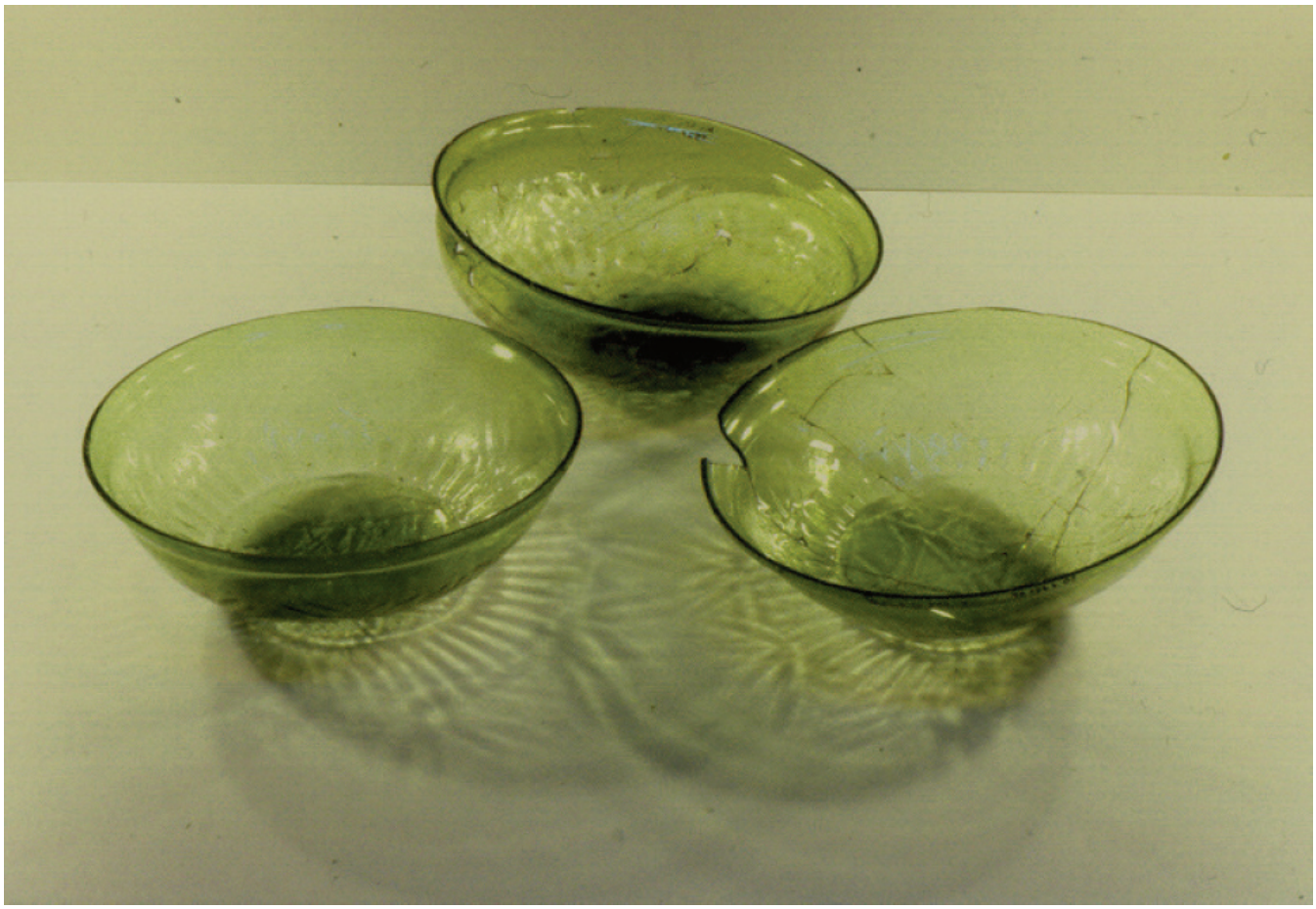


Fig. 2.13: Mould-blown bowls with cross-hatched lozenges from HA 132 and Eschweiler-Lohn (right) (photograph A.-B. Follmann-Schulz).

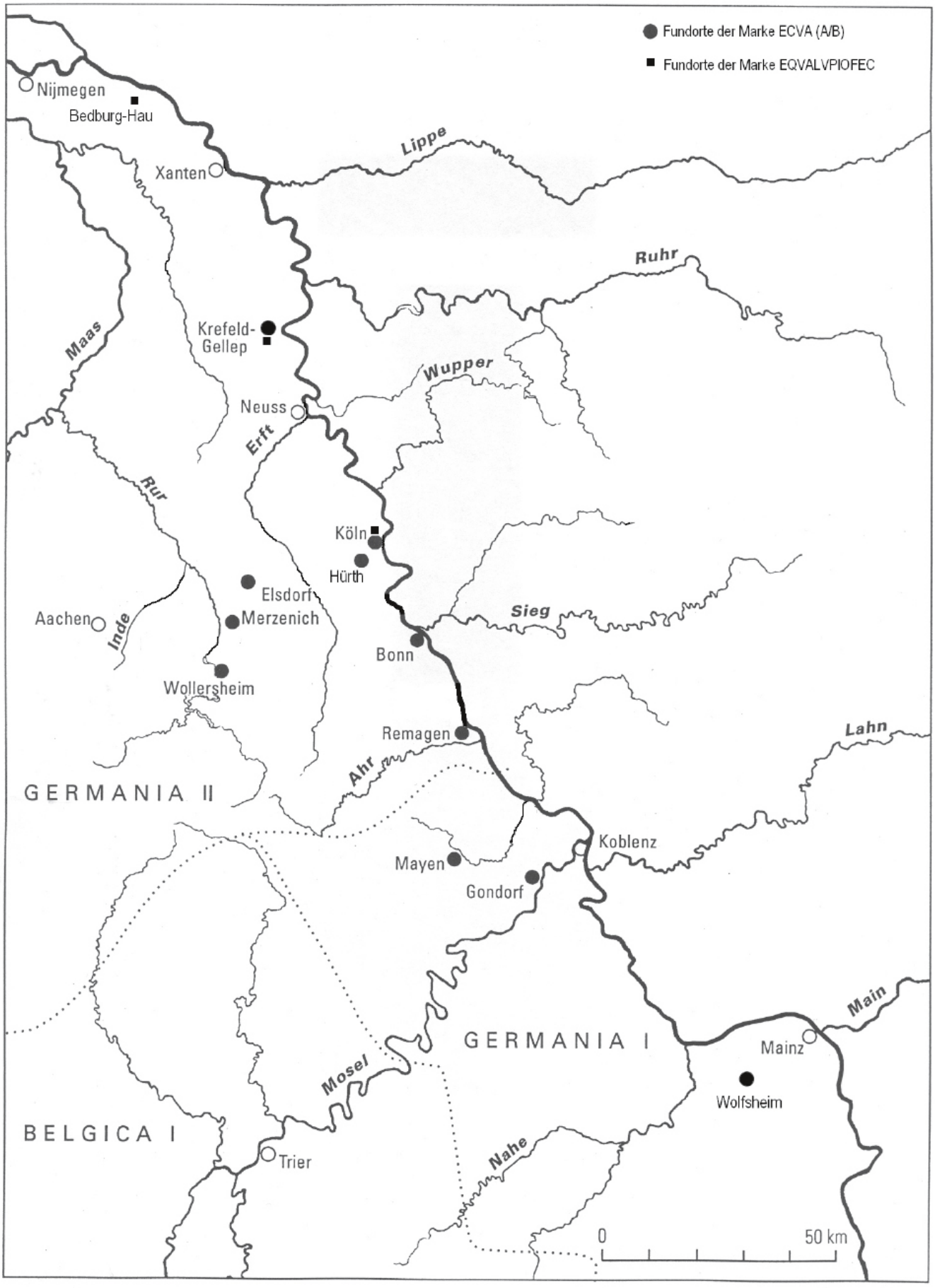

Fundorte der Marke ECVA (A/B)
Fundorte der Marke EQVALVPIOFEC
Nijmegen
Bedburg-Hau
Xanten
Lippe
Ruhr
Maas
Krefeld-Gellep
Wupper
Neuss
Erft
Rur
Köln
Hürth
Elsdorf
Aachen
Inde
Merzenich
Sieg
Bonn
Wollersheim
Remagen
Lahn
Ahr
GERMANIA II
Koblenz
Mayen
Gondorf
Main
GERMANIA I
Mainz
Wolfsheim
Mosel
BELGICA I
Trier
Nahe
0
50 km

Fig. 2.14: Findspots of examples of the stamps ECVA (A/B) (circles) and EQVALVPIOFEC (squares) (drawing courtesy of Rheinisches Landesmuseum Bonn).

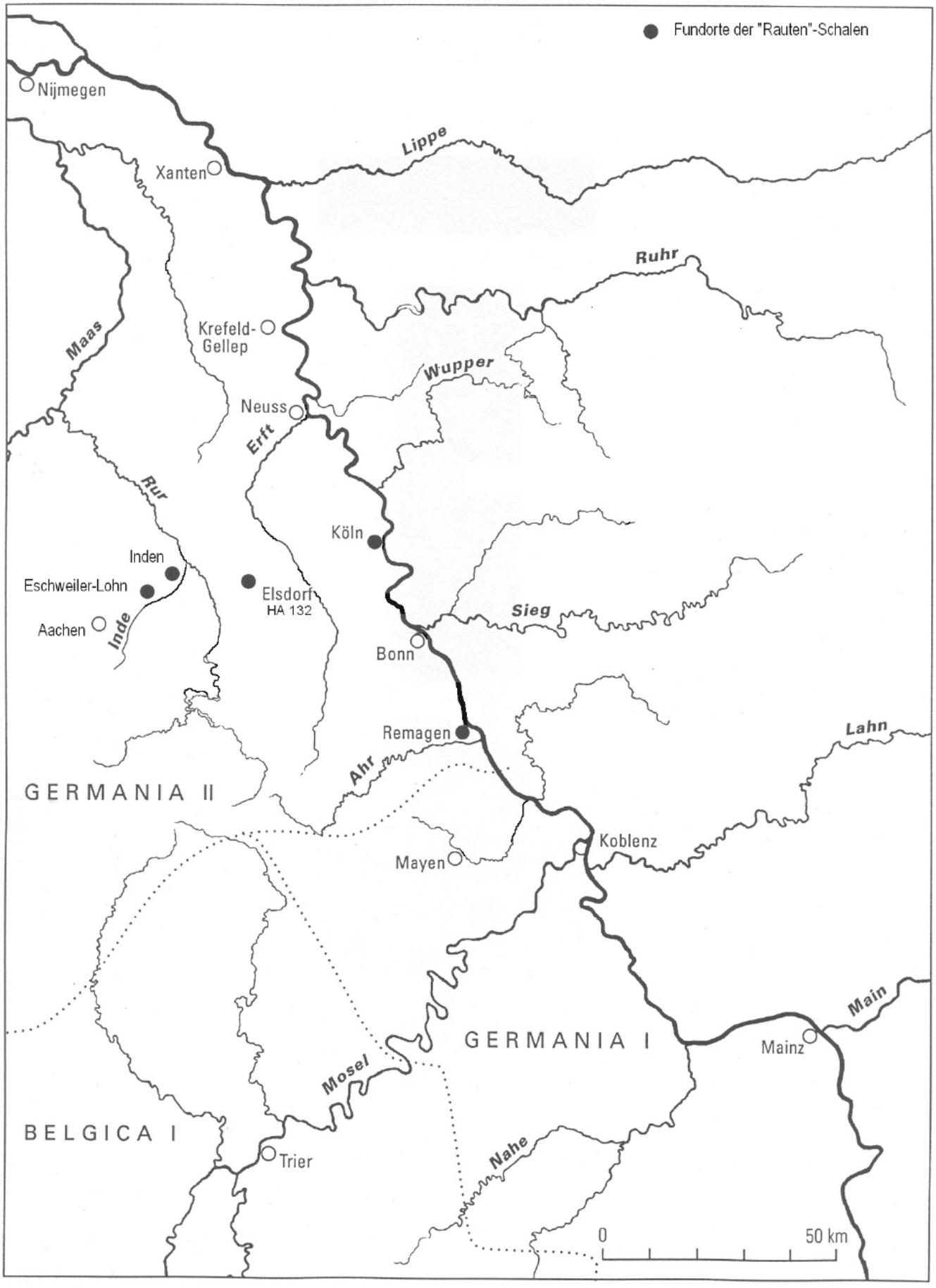

Fundorte der "Rauten"-Schalen
Nijmegen
Xanten
Lippe
Ruhr
Maas
Krefeld-
Gellep
Wupper
Neuss
Erft
Rur
Köln
Inden
Eschweiler-Lohn
Elsdorf
HA 132
Aachen
Inde
Sieg
Bonn
Remagen
Lahn
Ahr
GERMANIA II
Koblenz
Mayen
Main
GERMANIA I
Mainz
Mosel
BELGICA I
Trier
Nahe
0
50 km

Fig. 2.15: Findspots of bowls with cross-hatched lozenges (drawing courtesy of Rheinisches Landesmuseum Bonn).

Acknowledgements

I am much obliged to Clive Bridger-Kraus and the editors for correcting the English text. I warmly thank Wolfgang Gaitzsch for help and encouragement, and Marion Brüggler, Christiane Dirsch, Raymund Gottschalk, Ursula Heimberg, Sibylle Friedrich, Bernd Päffgen, Janina Weit and all the others for various information and assistance. I would like to thank Bernd Päffgen for his kind permission to publish the Altinden bowl here.

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Fig. 2.16: Bowl fragment (and plaster cast) from Remagen, RLM Bonn Inv 28978 (38) (photograph A.-B. Follmann-Schulz).

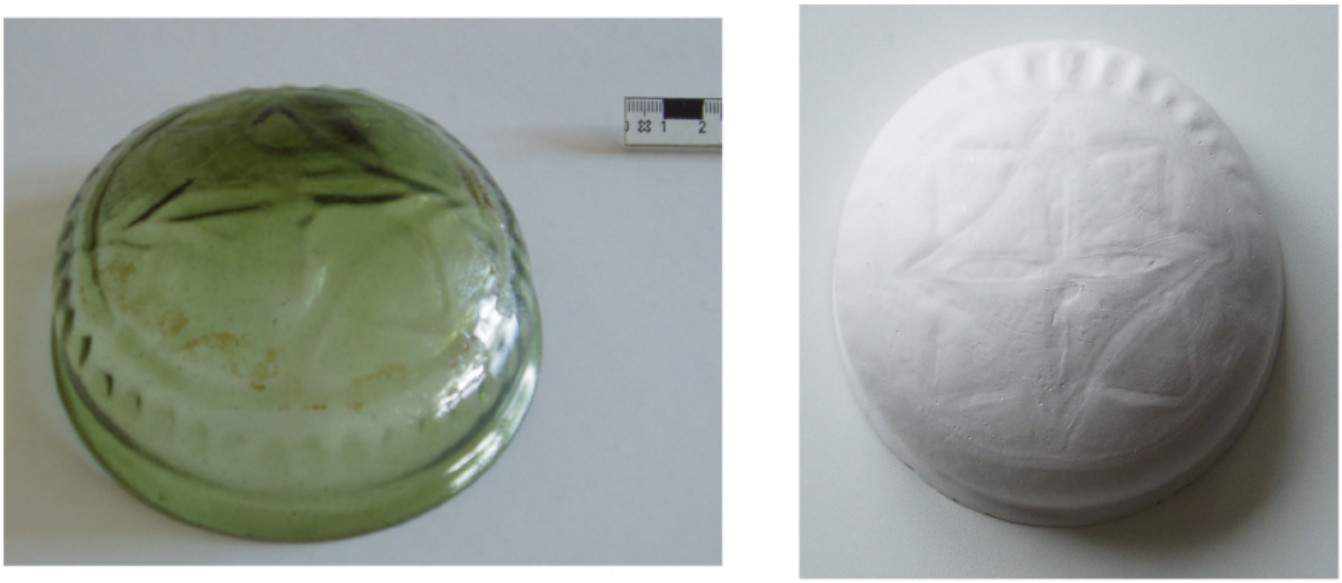

Fig. 2.17: Bowl with lozenges (and plaster cast) from Altinden, WW2004/61, St 609–07 (photograph A.-B. Follmann-Schulz).

3

A GAZETTEER OF GLASS WORKING SITES IN ROMAN LONDON

John Shepherd

Over twenty years ago, at the fourth congress of l'Association Française pour l'Archéologie du Verre held in Rouen in 1989, I summarised the evidence known at that time for Roman glass working in London (Shepherd and Heyworth 1991). Since then, and perhaps not surprisingly, a great deal of new information has been recovered from excavations in London. The aim of this paper is to bring up to date the ever-growing catalogue of evidence for the glass industry in Roman London. I am particularly pleased to be able to present this to Jenny as it has been her guiding authority that has helped me, and many of my Roman London co-workers, to unravel the meaning of so much of these data.

Introduction

In 1989 the evidence for glass working in Roman London could be summarised as coming from thirteen sites, which could be grouped into five geographically and chronologically distinct areas. Each group was on the fringes of its contemporary city and, apart from possible crucible fragments from the latest, 3rd or 4th century, group the main furnace technology for working glass relied upon the use of tanks. There was no evidence for glassmaking – cullet was the main raw material – although Mike Heyworth suggested at the time that there might have been efforts to improve the quality of the glass batch. Waste material suggested a wide-ranging repertoire, including some basic tablewares, but primarily utilitarian vessels. Naturally coloured glass was the only metal worked and there was the potential that some of the bulk glass was being imported in lump form. No evidence for glass working existed in Southwark, on the south side of the River Thames.

Since then, the total London assemblage has increased to 25 sites, the increase comprising seven minor sites as well as five major assemblages. The latter occur at Gresham Street, Guildhall Yard, Northgate House, Regis House and Basinghall Street. Three new zones can be identified and two others, previously regarded as ephemeral, have taken on a greater significance. Finally, the evidence from the Upper Walbrook valley region continues to increase in volume emphasising its importance as a prime glass working location.

Before reassessing the evidence extant in the City of London in 2007, a brief word is required about the only potential evidence for glass working in the City that was believed to

exist prior to the 1980s. This was at Clement's Lane and was found sometime during 1865–78 (Merrifield 1965, 278, no.288). A quantity of Roman glass, glass slag and an iron mould have been held up to be evidence that glass was manufactured there. Unfortunately none of this material survives for re-assessment. The mention of glass slag might simply refer to vitrified furnace fragments from any high-temperature industry, and as for the iron mould, none are known among Roman assemblages. It is likely that, whatever this object was, it belongs to a later period. The presence of numerous glass fragments is of interest, but whether they are a domestic assemblage or part of a cullet dump we simply will never know. It might be significant that, in retrospect, this discovery does not fall within any of the areas with definite evidence for glass working – but this is inconclusive. Unless the material can be rediscovered for study, this find must simply remain 'on file'.

The nature of the evidence

Before presenting a brief description of the information for each site in their respective geographical groupings, four important points must be stressed, as in 1989.

Furnaces

Firstly it has been previously reported that no furnace had been found *in situ* which could definitely be identified as being used for the working of glass. Only at Old Bailey (site 5) has anything approaching an extant furnace been discovered – but this was only identified as belonging to the glass industry during the post-excavation phase of the project, so it was not examined *in situ* as a glass furnace. In any case, the site was excavated under very difficult conditions and had to be completed so quickly that a full and thorough record of all the archaeological features is lacking. Since 1989, only one furnace has been found. This came from Regis House (site 2) but it was so severely truncated by later occupation that it provided very little information. Largely, therefore, the situation remains the same – we have yet to examine in detail a glass-working furnace in London.

Much redeposited material has been found which demonstrates furnaces were originally present. Other factors, working singly or in combination, are probably relevant here. Firstly, structural remains associated with the Roman glass industry, when they have been found elsewhere, are small – once dismantled just the base of the fire box and flue might survive. Another possible factor is that the programme of excavation which often has to be employed by the archaeological contractors working in London – selective excavation of large areas – might, as we will see on the Moorgate sites (sites 12 and 13), result in large quantities of waste material being recorded but gives only a hint as to the whereabouts of the furnace site or sites themselves.

Also, there is a phenomenon that is not unique to Londinium but is likely to be a feature of urban industrial sites rather than their rural counterparts. This is changes in land use in urban zones during the Roman period itself, whereby earlier industrial zones became absorbed and overbuilt by expanding residential areas; often this included the total dismantling of earlier structures and the relandscaping of the local topography. The debris resulting from such activity was then disposed of in neighbouring pits, ditches and streams or scattered in horizontal dumps. Although it might not be the case with the horizontal dump deposits, the material concealed in the other context types escaped later disturbance and thus survives to be included in the archaeological record. Perhaps redeposited debris is the best we can expect from an intensively occupied site such as Londinium.

Glass working

A second point to remember is that, for Londinium, there is as yet no definite archaeological evidence for the making of glass from raw materials. Mike Heyworth's observation that there appeared to be an intentional selection of materials to achieve a more colourless glass might be the only sort of evidence that, in London's case, we should expect. Rather than waiting for the fortuitous discovery of whatever it is we need to identify glassmaking itself, it might be more productive to conduct more in-depth study of the glass of the moils and other associated material for evidence of subtler chemical changes to the reworked cullet batch.

Thirdly, and of prime importance to the technologist, even though the ceramic assemblages from each site have been examined thoroughly, only one possible candidate for a glass working crucible has been recorded. This was the case in 1989 and remains the case in 2007. This single fragment comes from the 3rd- or 4th-century group at Norton Folgate (sites 20 and 21). All the evidence, from the 1st and 2nd centuries, suggests that tank furnaces alone were being employed in Londinium.

Finally, whereas in 1989 all of the glass from the London sites associated with glass working was of the naturally coloured variety (*i.e*. the common greenish blues etc), this is no longer the case. There is now evidence in the Upper Walbrook valley (Area VI) for the making of colourless vessels, and a few yellow-brown and blue moils from the same region suggest that there was a very limited production of coloured vessels. Furthermore, the only decorative technique to be tentatively identified is the application of self-coloured trails – but then, other than for some diagnostic waste fragments that suggest a particular form, it has proved difficult to assign fragments of vessels themselves to the London glasshouses.

Characteristic finds

Let us now briefly describe the types of object which interest us in the absence of furnace sites. Five general categories of find have been identified as indicative, when found together, of glass working.

Firstly there are the furnace fragments. These are of clay and tiles, burnt or fired to a greater or lesser degree according to their proximity to the heat source. These are distinguishable from hearth or furnace fragments associated with other industries quite simply by the glass adhering to their surfaces and filling cracks caused by the heat. This glass is not always recognisable as such but may be an opaque white, bubbly material resulting from glass being subjected to high temperatures, presumably for a long time.

The next category is the moil – a very distinctive object, conical or cylindrical in form, from the ends of blowingirons. The features to note are:

- Very bubbly and streaky glass
- A distinctive fracture at one end where the moil has been snapped from the iron pipe with a slight lip on the inside
- The opposite end often cut across or, if reheated for use, is fire-rounded

Thirdly we have pot-metal. This is simply bulk, unfashioned glass, broken from crucibles or tanks for remelting and occurs as small multi-angular lumps. The fine quality of the bulk material from the Tower of London site does make one wonder whether raw glass was being imported into London in this form, perhaps from some great distance.

These are the three main types of waste, which we recorded on the sites referred to below. Where any of these three categories (furnace waste, moils, pot/tank metal) occurs we also

examine two other types of object more closely; droplets and heat affected miscellaneous fragments, and fire-distorted vessel fragments. But of course, caution must always be exercised when interpreting these classes of object since they could simply be accidentally burnt fragments not associated at all with glass working.

One category of finds that we have sought, but are always careful when assigning them to any industry, are metal tools. Nothing resembling a blowing iron has been found but shears and pincers have been and one or two are known from sites with glass working debris, but it is not possible to assign them to the glass industry.

The following, therefore, is a catalogue of the sites from London that have produced the three main categories of waste material – furnace fragments, moils and bulk glass – together with droplets and threads. The sites are arranged according to each geographically and chronologically separate area and are arranged in chronological order. Fig. 3.1 locates the sites according to the gazetteer number given below.

The gazetteer

Area I. Gresham Street

1. 10 Gresham Street, EC2 (GSM97)

Excavated by the Museum of London Archaeology Service, 2000–01

NGR: TQ 3228 8133 (GLSMR: 085156/085161)

Excavations revealed a small 'native' style settlement consisting of several roundhouses alongside two small rectangular buildings. One of the roundhouses contained evidence for the manufacture of native style beads using recycled Roman glass. The settlement was occupied from AD 50–60. The waste included distorted bead fragments as well as beads in a number of stages of manufacture (Fig. 3.2). Contemporary with them were a number of fragments of blue Roman glass, especially pillar-moulded bowl fragments, as well as naturally-coloured fragments.

Area II. Regis House

2. Regis House, 39–46 King William Street, EC4 (KWS94)

Excavated by the Museum of London Archaeology Service, 1995–6 (Greenwood and Maloney 1996, 5)

NGR: TQ 3288 8074 (GLSMR: not known)

Excavations revealed a massive quay, constructed in AD 63, running across the foreshore. Set 4m north of this quay was a block of at least six rectangular buildings. These were interpreted as warehouses, although from an early date some appear to have been used as workshops. One, for example, had a small furnace installed, which was used to make twisted glass stirring rods, small glass bottles and drinking vessels. The working layers associated with the furnace contained glass moils, droplets, trimmings and numerous fragments of vessel glass, probably cullet. Also associated with this assemblage were some lumps of blue glass, which appear to have been used for the making of naturally coloured and blue twisted rods (Fig. 3.3). This activity continued for only a short period of time, probably not beyond AD 70. It probably represents the presence of a glassworker who took up residence with his family in one of the workshops. On current evidence, whether he had travelled from abroad or was a local from Britannia who had acquired, somehow, the skill to blow glass, he would be the first glassblower ever to work in Britain.

Area III. Watling House, Walbrook and Plantation Place

3. Plantation House, Chesterfield House (will be Plantation Place), 26–38 Fenchurch Street, 1–16 Mincing Lane, 23 Rood Lane, 53 Great Tower Street, EC3 (FER97)
Excavated by the Museum of London Archaeology Service NGR: TQ33188087 (GLSMR: 044842–51)
A few fragments of glass working debris were found in Flavian contexts and later across the site, evidently redeposited from glass working nearby. (A. Wardle, pers. comm.).

Fig. 3.1 Map locating the sites. The numbers refer to the gazetteer entries.

4. Watling House, 12–16 Watling Street/31–37 Cannon Street, EC4 (GM213)
Excavated by Guildhall Museum, 1954 (Shepherd 1986)
NGR: TQ 32304 81074 (GLSMR: 040554–70)
Watling House was one of a number of sites examined by Ivor Nöel Hume in 1954 under particularly difficult circumstances. The main Roman features on the site were the foundations

of a building that burnt down, probably during the Hadrianic fire episode in the City. Beneath this building, however, were a number of features including a single pit dated on ceramic evidence to the Neronian or early Flavian period. The pit contained a quantity of glassworking waste consisting of a few furnace fragments, moils, pot metal, and droplets, as well as numerous naturally-coloured broken vessel fragments. It may be significant that amongst the over 150 vessel fragments from the layer that contained this waste, there were just two that fitted together. Could this glass have been the remains of a batch of cullet? Unfortunately, the difficult conditions prevented the recording of any features associated with this pit apart from the remains of the Flavian building, which effectively sealed it.

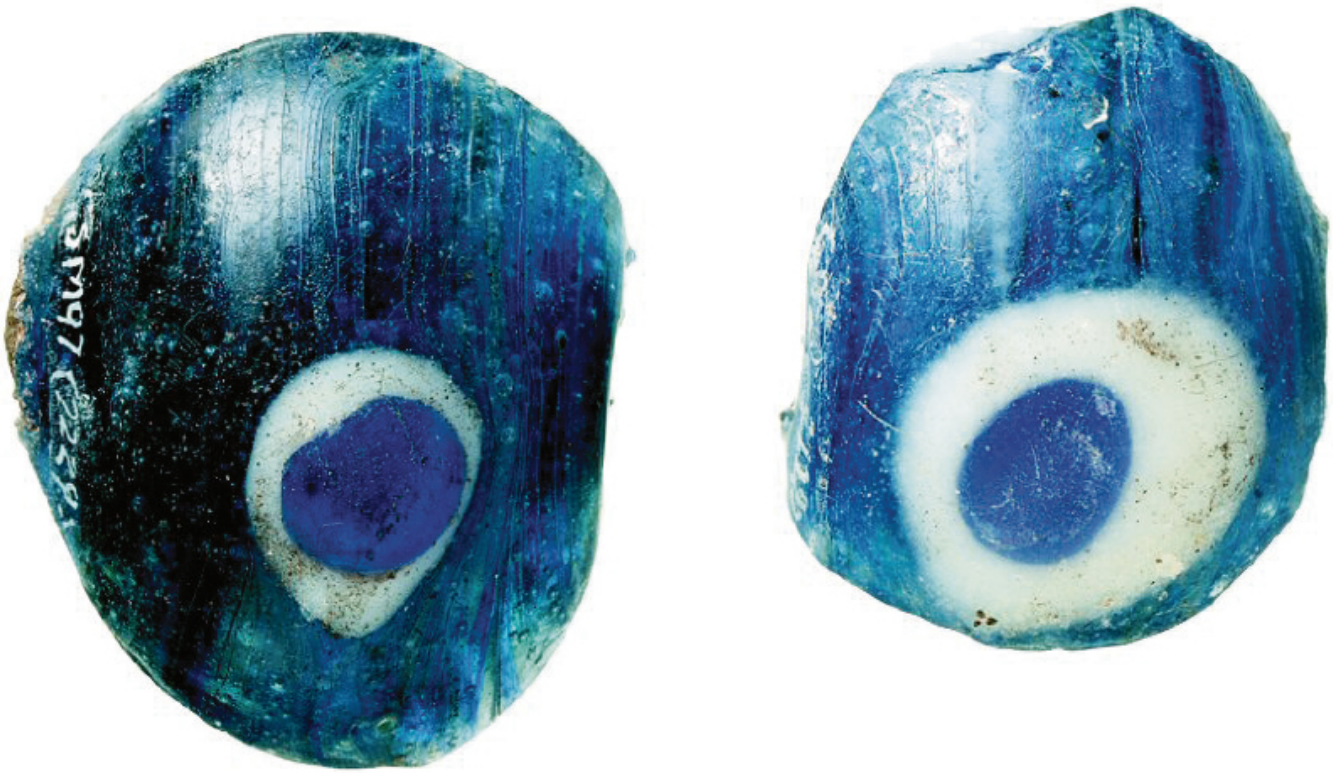

Fig. 3.2 Two distorted beads from among bead-making debris at Gresham Street (Gazetteer site 1).

5. The Walbrook: St Swithin's House, Walbrook House and Granite House, 30–37 Walbrook, 97–101 Cannon Street, EC4 (WAO06)
Excavated by the Museum of London Archaeology Service.
NGR: TQ32640 80960 (GLSMR: not known)
A single context contained a quantity of glass working debris, including cylindrical moils, lid moils, droplets and threads (A. Wardle, pers. comm.).

6. Bucklersbury House redevelopment site/Temple of Mithras, EC4 (WFG44/45)
Excavated by the Roman and Mediaeval (sic) London Excavation Council, 1952–54 (Shepherd 1998)
NGR: TQ 32590 80995 (GLSMR: 040871)
During his excavations of the famous Walbrook Temple of Mithras, Prof. W. F. Grimes never lost sight of his original project objective, namely to examine the extent and profile of the Walbrook valley across the large redevelopment site of Bucklersbury House. To this end, he ensured that his sections penetrated beneath the levels of the Mithraeum and down to the

natural surface of the valley. As a result he recovered a full sequence of occupation down to c.AD 60–70. Amongst the lowest deposits, dated to the late first or early second centuries (with the emphasis on the late first century), was a small assemblage of glass fragments, including a near complete lid-moil (Shepherd 1998, 127; Fig. 3.4). It was found together with five other moil fragments, one other lid moil fragment, three distorted fragments of waste and a single thread, all in natural greenblue glass. There were also 72 fragments of glass from the bodies of a variety of vessels, such as square-sectioned and cylindrical bottles, flasks and beakers, probably representing cullet. As with the Watling House material above, there were no joins among this material.

Fig. 3.3 Stirring rod fragments, some with blue spirals, from Regis House (Gazetteer site 2).

Area IV. Old Bailey and Fleet Valley

7. 18–25 Old Bailey, 10–18 Bishop's Court, 29–37 Fleet Lane, EC4 (0BA88)

Excavated by the Department of Urban Archaeology, 1988 (Schofield with Maloney 1998, 277)
NGR: TQ 31720 81340 (GLSMR: 043785–91)
Sometime around AD 120 a series of small furnaces was established on a hill overlooking the river Fleet, located on the periphery of the contemporary city. It is possible that they were in use for as long as 80 years, being replaced towards the end of the 2nd century or early 3rd century by an octagonal-shaped building, probably a Romano-Celtic temple. Of the eight furnaces excavated, only one survived to any substantial extent. Considering that only a small part of this site was excavated, it is possible that originally there may have been many more similar furnaces in the vicinity.

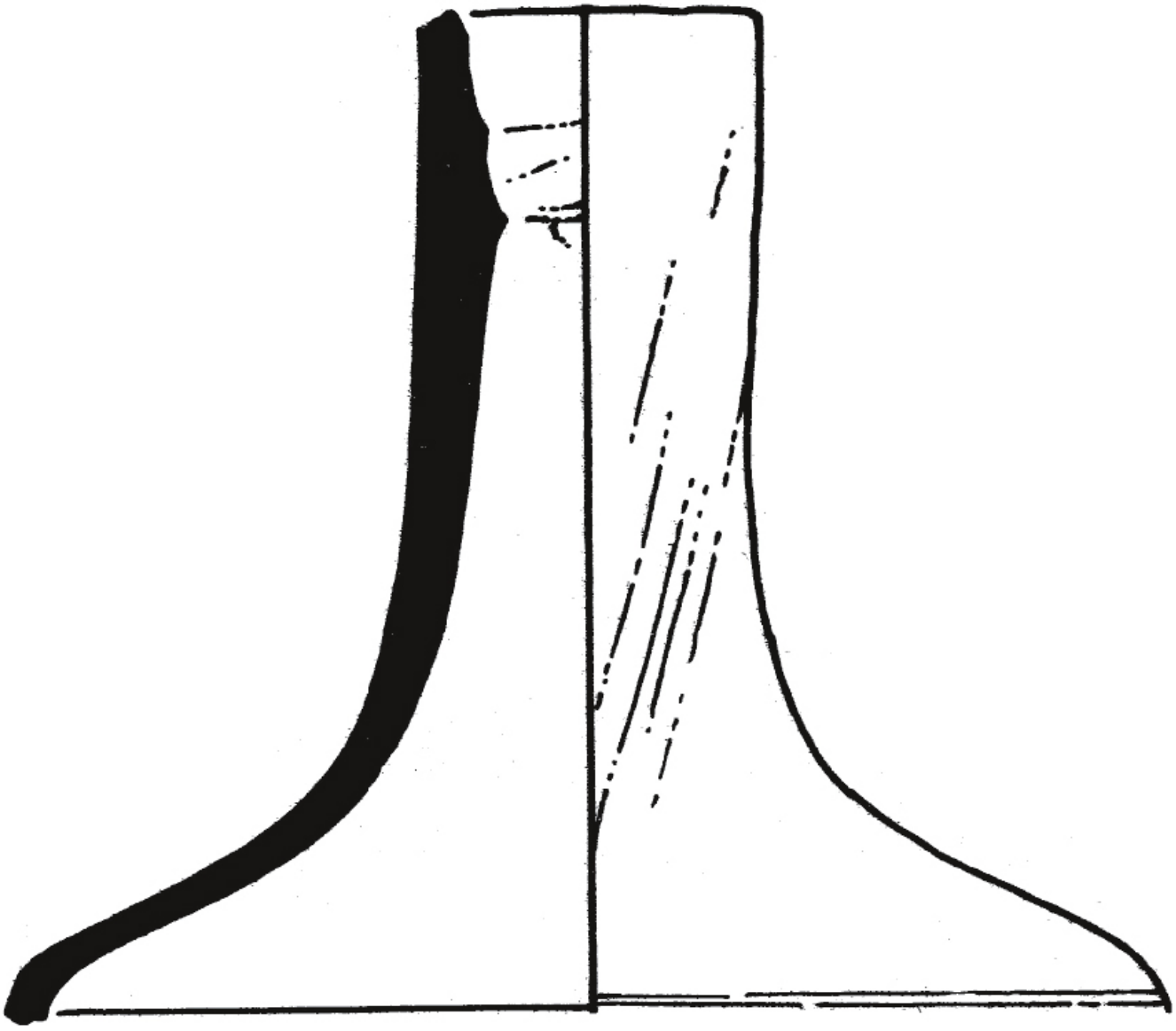

Fig. 3.4 The lid moil from the Bucklersbury House site (Gazetteer site 6). The lip end, originally attached to the vessel, is 75mm wide.

The one structure that survived to a significant extent was circular or oval in plan, with a small stoke-hole or fire box giving it a key-hole shaped plan, approximately 0.9m wide internally. It was sunk into the ground and lined with tiles, some of which were vitrified suggesting exposure to very high temperatures over a prolonged period of time. The presence

of sealed vitrified surfaces suggests that the furnace had been relined on at least one occasion, reducing the width to 0.55m internally.

The construction of the furnace is comparable in shape and size to the Mancetter furnace (Price 2005, 170, fig. 10.2), approximately circular with a flue to one side and a tiled floor. It too had been relined, reducing the internal diameter from 0.8m to an oval 0.51m by 0.34m and was found during the excavation of pottery kilns, which raises the possibility that the other structures in the close vicinity of the London furnace were for the production of pottery, though no other industrial waste, metal slags, pottery wasters etc were recorded.

However, a small quantity of debris from glass working: moils, threads, droplets, was found scattered through layers associated with the working lives of the furnaces. No crucibles were recorded. One would have expected waste from other processes if they had been carried out here, so the evidence as it stands suggests that all of these furnaces were used for the manufacture of glass vessels. Unfortunately, the glass waste was only processed and identified as such long after the site had been returned to the developers. It was not possible, therefore, to examine the structures as glass furnaces to secure additional data.

Of further interest is the presence of lumps of pot or tank metal among the *opus signinum* floor of the octagonal temple and a 4th-century building, which closed the Roman sequence on this site. It is possible that this material came from local preparation of raw materials for the brick and tile matrix of the *opus signinum*, re-using scattered furnace debris etc.

8. Fleet Ditch, somewhere between Fleet Gate and Holborn

Watching brief by John Conyers, 1677 (Brunby 1984)

Approx NGR: TQ 31670 80920 (GLSMR: not known) In the context of the Old Bailey site, it is important that we take note of a startling antiquarian find of 1677. As for the 19th-century Clement's Lane material, and perhaps not surprisingly, none of the material found in the 17th century survives for re-examination.

Mr John Conyers, an apothecary in Shoe Lane, was a passionate antiquarian who collected not only for his own pleasure but was willing to display to the general public his large collection of artefacts and other curios he had collected, which included material from London. Conyers had acquired these objects himself during many visits to sites in the course of 'redevelopment'. He is most famous for his 1677 examination of the northeastern foundation trenches for the new St Paul's cathedral where he identified pottery kilns. At the same time, however, 'It was not only at St Paul's …that Conyers went peering into holes' (Brunby 1984, 68). He also visited the excavation of the Fleet Ditch in the vicinity of the nearby Old Bailey. The excavation was, he said, '…verry deep between the fleet gate & the bridge at holbourne & there next the clay or yellow sand 15 foot d(eep) was taken up of this red earthern ware cupps'.

'The Labourers tould me of som Remains of other such kind of small kills that was found up & downe nere the place of the other Pott kills & these had a funnel to convey smoake wch might serve for glass forneses for though not anyny potts with glass in it whole in the fornaces was found yet broken Crucibells or Vesls for molteing of glasses togeather with boltered glass such as is to be seen remaining at glass housen amongst the broken Glass wch was glasses spoyled in the makeing was there found, but not plenty & especially coloured & prepared for Jewel liek ornament but mostly such as for cruetts or glasses with a lip to dropp withall & that a greenish light blew collour & of anny sort of glass there was but little so that the glass worke might be scarsy for I thinke a hudnred tymes more of Potts was found to one of glass & the broken' (British Library, Harl. MSS, MS. 5953, f. 106r).

9. Sheldon House (former), Charterhouse Bank Building, 1 Paternoster Row, EC4 (PNS01)
Excavated by the Museum of London Archaeology Service.
NGR: TQ 32072 81228 (GLSMR: not known)
A small quantity of glass working waste, including cylindrical moils and droplets, came from early second century contexts (A. Wardle, pers. comm).

10. Juxon House, St Paul's Churchyard, Ludgate Hill, Ave Maria Lane, EC4 (SLY00)
Excavated by the Museum of London Archaeology Service.
NGR: TQ 3193 8118 (GLSMR: not known)
A small quantity of glass working waste, including cylindrical moils and droplets, came from early second century contexts (A. Wardle, pers. comm).

Area V. Newgate Street
11. 76–80 Newgate Street, former General Post Office, EC1 (GPO75)
Excavated by the Department of Urban Archaeology, 1975–9 (Schofield with Maloney 1998, 142–4)
NGR: TQ 32050 81350 (GLSMR: 043338–48)
The excavations revealed a sequence of buildings that were destroyed by fire during the latter part of the first quarter of the 2nd century AD. Many of the rooms had hearths, probably for heating and food preparation, but one had a large number of incomplete and fire-distorted melon beads associated with it. This is probably evidence of bead manufacture – however, the archive for this site has yet to be examined in detail so this interpretation is only provisional.

Area VI. Upper Walbrook
The sixth area is perhaps the most interesting and certainly the most important. It dates primarily to the first half of the 2nd century and is located in the upper reaches of the Walbrook stream. To the west lay the fort and the amphitheatre, to the south the residential areas alongside the roads crossing the Walbrook and to the east the municipal quarter of the city. In general, this region was very wet and marshy and was crossed by many small streams. It had been used as an industrial quarter for leather-working, small-scale metalworking etc. since the late 1st century and was served by roads coming from the residential zones to the south. A large amount of redevelopment has taken place in this particular area over the last twenty years and, consequently, the Roman deposits in the region have been well examined but glass working waste occurs in just a few of the sites. However, the volume of material is staggering. Once again this industrial zone is on the periphery of the contemporary, 2nd-century city – not yet walled at this date.

The products of the furnaces in this area have proved difficult to identify. Many moils ranging from 20–30mm in diameter have been recorded but none really assist in defining specific products. Some misshapen rim fragments from bulbous-bodied jars do exist and the cylindrical and thick nature of many of the moils might suggest bottle or flask production but for the time being, that is all that can be said. An interesting addition to this assemblage, however, is the presence of a number of distorted bead fragments and two spoilt spindle-whorl fragments. It would appear, therefore, that object production was being carried out alongside vessel production.

12. Black Swan Alley/London Wall, EC2
Watching brief by William Newton, late 19th century
Approx NGR: TQ 32760 81403

In 1912, a number of items donated by William M. Newton were accessioned by the London Museum. One accession (A2371, Newton Catalogue no. 361) is described as being eight fragments of glass-blowers floor 'by colour of glass Roman'. These were found at a spot that, in the Roman period, would have been *c*. 30yds from the position of the Roman City Wall. No other glass fragments were collected or noted by Newton and the only other find from this site made by him was a small 'bronze sheep bell'.

13. 2–3 Cross Keys Court, Copthall Avenue, EC2 (OPT81)
Excavated by the Department of Urban Archaeology, 1981 (Schofield with Maloney 1998, 171–3)
NGR: TQ 32750 81490 (GLSMR: 043384–96)
Working waste and small furnace fragments were found in a number of contexts on this site, but no concentrations were noted.

14. 43 London Wall, EC2 (LWA84)
Excavated by the Department of Urban Archaeology, 1984 (Schofield with Maloney 1998, 206)
NGR: 32730 81530 (GLSMR: 043170–3)
Waste material was found in a number of contexts across this site. No concentrations were noted.

15. 44 London Wall, EC2 (LDW84)
Excavated by the Department of Urban Archaeology, 1984 (Schofield with Maloney 1998, 204)
NGR: 32790 81400 (GLSMR: 043238–40)
Waste material was found in a number of contexts across this site. No concentrations were noted.

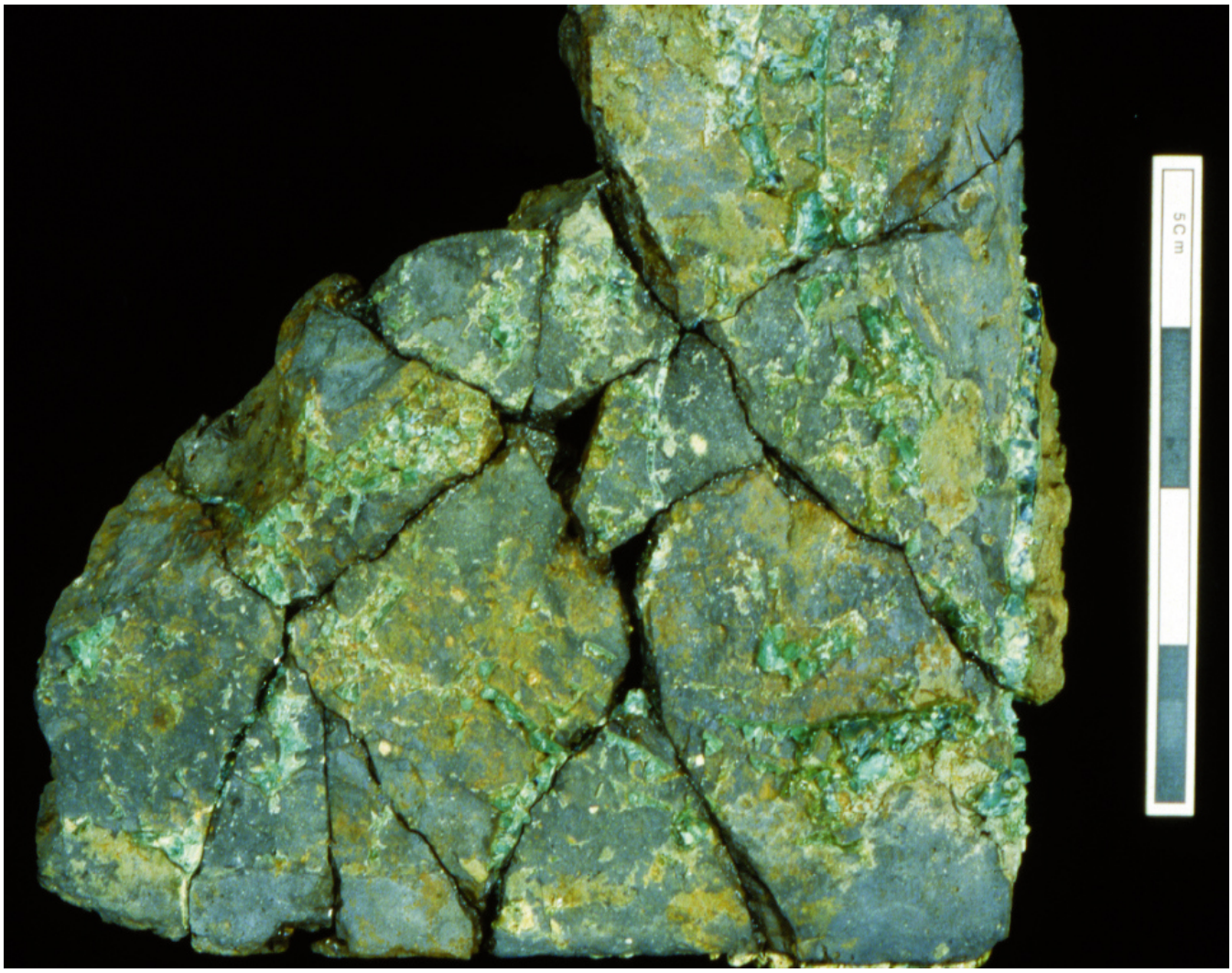

Fig. 3.5 Fragment from the floor of a tank from Moorgate (Gazetteer site 17).

16. 49–53 Moorgate, 72–74 Coleman Street, EC2 (MOG86)
Excavated by the Department of Urban Archaeology, 1986–7 (Schofield with Maloney 1998, 231)
NGR: TQ 32670 81470 (GLSMR: 043085–92)
Excavations on this site produced a quantity of glass working debris spread across a number of contexts. No concentrations could be identified.

17. 55–61 Moorgate, 75–79 Coleman Street, EC2 (MGT87)
Excavated by the Department of Urban Archaeology, 1987–8 (Schofield with Maloney 1998, 252–3)
NGR: 32680 81490 (GLSMR: 043995–4005)
Excavations revealed what might have been the remains, truncated in antiquity, of a furnace. Only a small area inside existing basements could be examined and subsequent reduction of the total basement area was carried out so rapidly that only the barest of watching briefs could be maintained. A timber building (or buildings) was discovered alongside a revetted stream. In the angle of two walls of this building there was a dense scatter of glass furnace fragments. Closer inspection of the surrounding floors revealed heavy signs of burning from a localised heat source. The furnace fragments, coming from an indeterminate number of

structures, were found scattered across the site, appearing in horizontal levelling dumps following the dismantling of the clay and timber building seen earlier and in pit, stream and ditch backfills; two are described below:

The first is an almost complete Lydian-sized brick, which has been used as the suspended base of a tank furnace (Fig. 3.5). Only the central area, where the glass remaining from the final melt has been smashed from the tank to leave pyramidal lumps adhering to the tile, represents the area of the tank itself. The surrounding area, up to the edge, is covered by glass but rounded on the top and covered by fired grey clay. This represents the vertical wall of the furnace above the base of the tank. It is apparent that during its initial firings the clay walls of the furnace contracted. Cracks and gaps revealed themselves between the partly-fired clay wall and the already-fired brick base and the molten glass seeped into these cracks. This glass continued to flow between the wall and the tile and seeped under the tile where it became heavily burnt producing the bubbly opaque white material referred to earlier. This process has preserved the shape of the vertical wall beneath the tile (which coincides with the same horseshoe pattern on the top) and, whether intentional or not, it would appear to have effectively sealed the underside of the furnace and prevented leakage from the tank into the firebox or flue below.

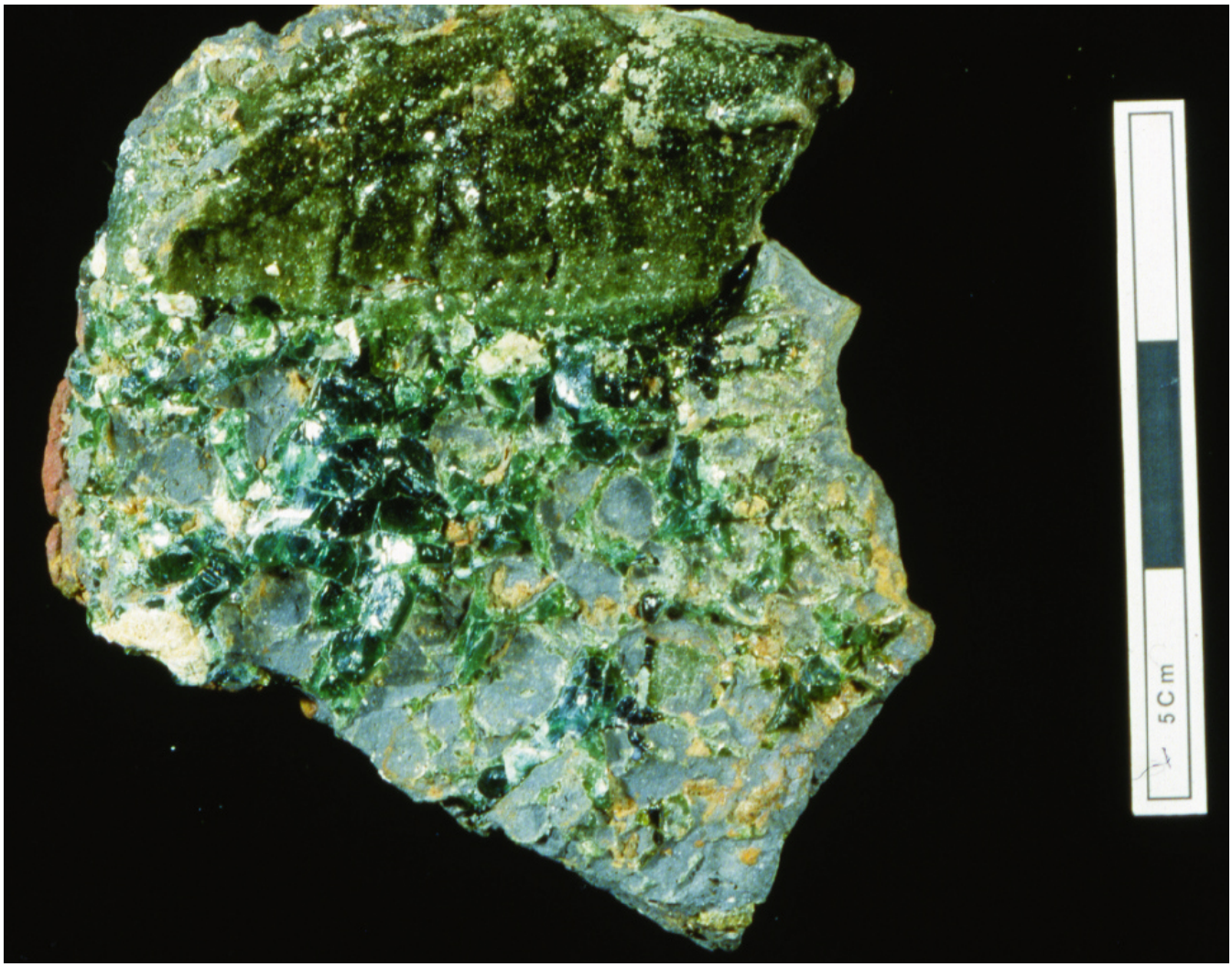

Fig. 3.6 Fragment from the wall of a tank from Moorgate (Gazetteer site 17).

The second fragment appears to come from part of a vertical wall of a tank furnace and shows clearly the horizontal level of the glass at its final melt (Fig. 3.6). It is interesting to note the high level of the glass because it shows that a large quantity of glass was allowed to cool in this particular tank. Was it the final batch of this particular tank or could it be that this is the wall of a fritting furnace for the preparation of the glass metal itself, from any source, before its contents were smashed from it and transferred to some other receptacle for working? Seen from the side, it is possible to detect the different degrees of firing of the clay wall and, once again, numerous cracks in the wall sealed by recognisable glass and the opaque white material.

18. Guildhall Art Gallery, Guildhall Yard; Portland House, 72–73 Basinghall Street, EC2 (GYE92)
Excavated by the Museum of London Archaeology Service, 1992–8 (Perez-Sala and Shepherd 2008)
NGR: TQ 3251 8136 (GLSMR: not known)
Excavations on the site of the new Guildhall Art Gallery revealed an amphitheatre. Outside the eastern entrance a series of drains had collapsed at their junction to form a shallow pool or pond. This had been backfilled with rubbish and debris, including a large quantity of broken vessel, window and glass working debris intended for recycling. This material weighed c.50kg, approximately 100,000 individual fragments of glass. None of the fragments was larger than c. 10 sq cm, many were small splinters and waste fragments. The main deposit was so densely packed with glass that this context (14319) can be described as 99% glass and 1% silt. This material was evidently a cullet dump and a date for deposition during the Hadrianic period is suggested, but until the full sequence on that particular part of the site has been processed this date must remain tentative.

In addition c.50kg of smashed furnace fragments were also found, but no *in situ* furnace was located on the site. There was still no evidence for glass making (from the raw materials), only glass working from recycled cullet. The main observations are:

- As a cullet dump containing vessels collected over a very short period of time (probably less than a single year) there is an excellent opportunity to reconstruct the range of vessels in circulation during the Hadrianic period. At the time of writing, this work has not yet started.
- The c.100,000 fragments contains the identifiable remains of over 2000 individual vessels coming from at least 60 main form groups. Many of these would have been made immediately before or during the Hadrianic period but the assemblage also contains fragments of what we know from elsewhere as Flavian and Trajanic forms. Thus this group helps to identify the longevity of particular vessel types from the mid 1st century to the third decade of the 2nd century; only a few pillar-moulded bowl fragments were present, for example.
- It is evident that naturally coloured glass was collected here for recycling but colourless and coloured vessels (normally regarded as higher quality vessels) have also become included. These make up less than 1% of the total but that still represents over 40 individual vessels. The majority of these are more commonly associated with Flavian assemblages.
- The glass working waste from the dump is the largest such assemblage ever found on a Roman site in the western Empire. It contains all the main categories of waste, especially a large collection of moils of different sizes and shapes, threads, droplets and a number of firedistorted fragments which might represent waste vessels being returned for recycling.
- The dump contains a large quantity of window glass and bottle glass, from square-sectioned and cylindrical bottles, which appear to have been the main source of glass for

this particular workshop. Interestingly, as for those sites described above, no joins could be made between any of the fragments. This suggests that the surviving material must once have been part of a much larger assemblage

One important question, however, remains unanswered. Why was this valuable commodity discarded? The exact circumstances of its deposition are not known but it is possible that it was dumped as part of a larger-scale reorganisation of the immediate area for new development (Perez-Sala and Shepherd 2008, 145).

19. Northgate House, 20–28 Moorgate, EC2
Excavated by the Museum of London Archaeology Service, 1995 (Keily and Shepherd 2005)
NGR:TQ 3272 8142 (GLSMR: 044141–4)
The glass waste, furnace fragments and a quantity of vessel fragments from this site were discovered in pits adjacent to a number of pottery kilns. This material was likely to be cullet for recycling. Once again, no evidence for glass making was found and there were no glass furnaces on the site itself. The assemblage is very similar in character to the material from 55–61 Moorgate (site 13), approximately 75m to the northwest, which was also dated to the first half of the 2nd century. Both sites produced a wide range of waste material, including large furnace fragments, and it is unlikely that either assemblage had travelled far and, given their similarity, probably derive from a common source.

20. 35 Basinghall Street, EC2 (BAZ05)
Excavated by the Museum of London Archaeology Service, 1995–6 (Freestone, Shepherd and Wardle in prep)
NGR: TQ 3255 8148 (GLSMR: not known)
These excavations have produced another large assemblage of glass working waste, the character of which is unlike any of the other material from the Upper Walbrook valley. Whereas Guildhall Yard produced mainly cullet, with a small proportion (but still many thousands of items) of glass working debris, and the two Moorgate sites and Northgate House produced waste material with furnace fragments, the Basinghall assemblage contains a much higher proportion of finer waste material, such as moils, threads, droplets, trimmings etc, which are more closely associated with the manufacturing process itself, rather than material gathered and sorted for recycling. The assemblage also contained moils in colourless and brown and blue metals. It is likely that this material derived from directly around a furnace – though no furnace site was discovered. The material dates to the first half of the 2nd century, possibly extending towards the end of the century.

Area VII. SE corner of city
The seventh area can be located in the southeast corner of the walled city and comprises three dumps of glass working debris deposited during the late 2nd or 3rd centuries.

21. Inmost Ward, Tower of London
Examined by the Ancient Monuments Branch of the Ministry of Works, 1955–6 (Bayley and Shepherd 1985)
NGR: TQ3236 8041 (GLSMR: not known)
One dump was found making up part of the internal bank of the landward city wall (built around AD 200) at Inmost Ward, Tower of London. The few furnace fragments from this site suggest a technology similar to that used in the Upper Walbrook valley. The range of moils is

greater and may indicate a far larger repertoire. The quality of the pot/tank metal from this site was far better than that seen anywhere else in the city.

22. St Dunstan's Hill, 84 Lower Thames Street, EC3 (GM163)
Examined by the Guildhall Museum, 1967 (Schofield with Maloney 1998, 90)
NGR: TQ 33150 80675 (GLSMR 044365/044434)
Another dump lay slightly further to the west and was part of the foundation of a minor road alongside a small 3rd-century building in St Dunstan's Hill. Just a small but perfect moil survives from this dump, along with a reference in the site notes which describes the moil as coming from a layer containing 'large quantities of crushed and broken glass'.

23. Colchester House, Savage Gardens, Pepys Street, 9 Cooper's Row, EC3 (PEP89)
Excavated by the Department of London Archaeology and Museum of London Archaeology Service, 1989–1992 (Schofield with Maloney 1998, 295)
NGR: 33520 80830 (GLSMR: 042832–5/044065–72)
Excavations produced a small quantity of glass working waste scattered among a number of contexts.

Area VIII. Norton Folgate
24. 1–3 Norton Folgate (NRT85)
Excavated by the Department for Greater London Archaeology (N), 1985
NGR: TQ 3340 8192 (GLSMR: 081095–6)

25. 4–12 Norton Folgate (NRF88)
Excavated by the Department for Greater London Archaeology (N), 1988
NGR: TQ 3341 8196 (GLSMR: 080934/082271)
Area VIII is an extra-mural dump dating to the 3rd or possibly the 4th century. It contains the type of debris described above but, in addition, has a single fragment of pottery with a thin skin of glass adhering to it. This is our only candidate from the whole of the city for a glass-working crucible.

Provisional conclusions
A full and thorough examination of all of the glass working debris from Londinium is soon to get underway, so any observations given here are provisional in advance of the results of this work. However, it is possible to make a few statements.

The earliest evidence for glass working in Londinium is the bead production in Area I at Gresham Street in *c* AD 50–60, probably by native peoples. Around c.AD 65–70 a glassworker took up residence in a warehouse on the Regis House riverfront (Area II), blowing small bottles, drinking cups and making twisted stirring rods. Similar blowing activity, but perhaps just a little later into the Flavian period, took place in Area III, the middle Walbrook valley, at Bucklersbury and to the west at Watling House. The former was on marginal ground alongside the Walbrook stream, the latter on the fringes of the contemporary city.

Towards the end of the 1st, or during the early 2nd century, glassworkers set up their furnaces in Area IV on the extreme western side of the city at Old Bailey. A sequence of intercutting furnaces might be evidence for peripatetic workers returning to the same locations over a period of time (J. Price, pers. comm.). The full extent of this production is not known, the exigencies of rescue archaeology and truncation have dramatically reduced the

archaeological record. However, it is likely that the activity was quite substantial. Just to the east in Area V, melon bead production was being carried out at the General Post Office site.

At around the same time, the Upper Walbrook valley (Area VI) was used by a number of industries, among them glassworkers, who worked for a number of generations throughout the 2nd century. It is not known if they were permanent or seasonal residents in the area; this has yet, and somehow, to be deduced. They left behind remarkably large assemblages of waste material that is the subject of a future study, based around the Basinghall material.

Towards the end of the 2nd century, glass working appears to have moved to Area VII, the southeast corner of the city around the Tower of London. Finally, some redeposited material including a possible crucible fragment occur in 3rd- and 4th-century dumps in Area VIII, far out of the city at Norton Folgate.

The general trend, therefore, is for the glass workshop area to be located on the marginal land of the city, often associated with other industries. It should be emphasised that this study has taken into account all of the glass assemblages from the London area; nothing remotely similar to any of the city assemblages has been recorded south of the river in Southwark.

This brief survey has summarised information from the many sites across the city and, hopefully, has prepared the way for further work on the glass working industry in Londinium; there is certainly much scope for further analysis and study.

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4

PROVENANCE STUDIES AND ROMAN GLASS

Caroline Jackson and Harriet Foster

> Although glass working took place in virtually every area of the Roman world, the evidence for glass production is generally rather difficult to identify and interpret. There is a marked contrast between the wide range of vessels and objects, which survive complete in burials or, more frequently, are found in fragments on settlements, and the ephemeral and episodic nature of the evidence for the production processes by which they are formed (Price 2002, 81).

This short observation by Jennifer Price epitomises our knowledge of the production and consumption of Roman glasses almost to the present day despite many years of serious archaeological and scholarly endeavour. Glass of the Roman period, however, cannot be singled out as an unusual case. Glass studies in general have yielded complex and sometimes ambiguous observations which have given rise to contradictory or competing interpretations. This makes glass an extremely interesting, challenging and rewarding material to study.

Roman glass studies are, by their nature, linked intimately with the history of ideas of technology and social development. They also directly investigate the residues of past production and use through the study of artefacts. The production and consumption of artefacts, certainly in antiquity, is often seen as an indicator of social transformation and complexity. Indeed, the invention and adoption of glass, and changes in the way it is assimilated and used within society, mimics the development and growth of the Roman Empire (Fleming 1999). In more recent years new archaeological discoveries and a growth in scientific and theoretical studies relating to glasses have expanded our understanding of this material, how and where it was made, where it was traded and who used it. In parallel with this development by established scholars in the subject, there has been an increase in the number of students who study glass from a much wider geographical area, and a growth in inter- and intra-disciplinary studies. This paper acknowledges the expansion of this dynamic field and will examine in more detail the contribution of scientific studies of Roman glasses to our understanding of Roman economy and society.

Where the fields of metallurgy, pottery and other manufactured goods have rapidly become a rich source of material for social theorists within archaeology who delve into the people behind the processes, Roman glass has suffered from a lack of tangible evidence for production and trade on which to base similar interpretations. With ceramics we can link stylistic traits and distributions of pots to their place of manufacture, and match their clay bodies to local geology to reinforce this patterning. Using this information we can trace the movement and consumption of these pots on a large scale, or even between individuals in a

community. In this way, pottery is relatively straightforward in terms of provenance studies because the location of production and the clay source are often intrinsically linked. Glasses pose a different problem. Unlike ceramics, glass can be remelted and recycled, and the production process may involve more than one stage and more than one manufacturing location. For example, glass may have been manufactured from its raw materials, alkali and sand, in one location, whilst shaping operations may have been at a different workshop at a considerable distance. Thus the organisation of production, the number of people or centres involved, and the network of supplies of raw materials and manpower, may have been very varied; our interpretation of glass assemblages depends on whether we accept that glass was manufactured at one location and worked at one or more other centres, or manufactured and shaped at the same place. Moreover, we have evidence, excavated over the last century and more, for consumption of glass in the Roman world, by households, by the military and by different social groups. This is reinforced by written sources that record the rise or decline of glass through time as a fashionable or utilitarian commodity. However, at present our knowledge of who produced these commodities, where they were produced and in what context is in its infancy – and there are other unanswered questions: how did these commodities reach their destination and did they travel by similar means, who controlled the movement of trade, and were these commodities generally moved en-masse or as sets destined for particular markets or a by a variety of means? By examining the contribution that glass studies can make to our understanding of Roman society and economy, this paper will also consider how we may begin to address some of these questions.

The study of Roman glass

The study of the origins of Roman glass production and use date back further than modern archaeological or scientific practice. Historical accounts document stories which had become folklore even at that time. Pliny, who had a fascination with the earth, its treasures and its materials, recounts the apocryphal tale of the discovery of glass by Egyptian natron traders by the sands of the River Belus where the alchemy of fire, sand and salt produced this magical new material. In other sections he describes the use of specific raw materials in glass production; for colourless glasses, he says glassmakers used sands from the Volturno River in the Campania region of Italy (*Natural History* 36.193–4). But while Pliny mentions a few select regions where raw materials were procured for glasses, he does not state where the glass was made, although it is likely he knew, as the following quote suggests. 'Glass, like copper, is smelted in a series of furnaces, and dull black lumps are formed…' and 'After being reduced to lumps, the glass is again fused in the workshop and is tinted.' (*Natural History* 36.193). This reference is a tantalising glimpse into a complex multi-stage process, glass melts taking place in a series of furnaces, which produce lumps of fused material which are re-melted, colour added and then reworked in workshops.

The lack of extensive production evidence in the archaeological record led academic study in more recent times to focus on the available artefactual evidence. This is illustrated by early- and mid-20th century studies which examined the development of the Roman glass industry (from the 1st century BC through to the 4th century AD and later), in terms of the range of vessels and coloured glasses produced and the techniques used to form vessels (*e.g.* Fremersdorf 1958a; 1958b; 1961; 1962; 1967; Harden 1936; 1956; Isings 1957; Morin-Jean 1913). Several publications, particularly in the last twenty years (*e.g.* Arveiller-Dulong and Nenna 2005; Cool and Price 1995; Foy 1991; Foy and Nenna 2006; Fleming 1997; 1999; Grose 1989; Harden 1987; Newby and Painter 1991 and authors therein; Price & Cottam

1998; Stern 1995; Whitehouse 1997; 2001; 2003; as well as a series of papers presented in *Kölner Jahrbuch* 22, 1989), have provided a synthesis of this body of knowledge. Many of these studies have looked at consumption assemblages of glass found on Roman sites. These studies have identified glass distributions through time and geographical space and have mapped the patterns seen in the archaeological record (e.g. Cool and Price 1995). For glass studies in Britain, early work by Donald Harden provided a real impetus. Later research by Jennifer Price, both individually and with Hilary Cool, Sally Cottam and Sally Worrall as part of the Romano-British Glass Project, has made one of the greatest contributions to this study for over 35 years, and covers work throughout Britain and the Mediterranean. Her numerous published works have informed Roman glass studies internationally (e.g. Price 1974; 1976; 1978; 1990; 1991; 1995; 2002; Price and Cottam 1998; Price and Cool 1991 and countless other catalogues and review papers synthesising and developing the subject) and they, along with her enthusiasm for sharing this knowledge, have provided inspiration for many papers including this one.

Analytical studies of Roman glasses

This established heritage of studies in Roman glass provided a catalyst for scientific and analytical research. The 1950s marked a significant development in these early studies, by bringing together, synthesising and taking forward the body of knowledge on the composition of ancient glasses which was based on studies dating back to the late 18th century. Scholars from the fields of glass technology, chemistry and physics such as W. E. S. Turner, Ed Sayre, Fred Matson and Wilhelm Geilmann were the leaders in this early work. These scientists were intrigued by these early glasses. They had the knowledge of scientific techniques, and saw a place for these in the field of archaeological endeavour. Driven by a techniques-based approach they explored the chemistry of early glasses, often choosing material which spanned large geographical areas and temporal periods, and a variety of glass types and colours within each period. It was not unusual to find a single paper studying glass from the Early Bronze Age to late medieval periods and Asia to northern Europe; this is typified by Sayre and Smith's (1961) seminal paper. The compositional trends they identified were defined by chronology or geographical area, or by culture (although this was not defined in social terms at this time, *e.g*. Geilmann 1955). These were the primary steps towards a description of glass compositions on a broad scale, and in some cases a first understanding of the technology of glass production at different periods, one which included the raw materials used to make the glass and the elements responsible for specific colours. While perhaps lacking in the more focussed and directed approach of modern glass studies, the legacy of this early research was huge. These first forays into compositional studies showed that early glasses were made from simple, naturally-found raw materials. In particular Sayre and Smith (1961) and Turner (1956) demonstrated that Roman glasses formed a cohesive group. Brill (1970b, 111) noted that this 'Roman glass' could be defined in terms of its mineral alkali which was low in potash and magnesia. They demonstrated that glass was produced, as Pliny had suggested, using low impurity sands and the evaporite salt which he termed 'nitrium', commonly known today as 'natron' or more correctly trona, and it was noted that this composition was homogenous throughout the Roman world and beyond for over six centuries. The initial steps to describing Roman glass had now been taken; these scientific studies had defined the characteristics of the glasses and suggested the raw materials used to make them, but they left the socio-cultural explanations responsible for the production and distribution of the material to their collaborators in the humanities.

Another notable step in scientific studies at this time is presented by Fred Matson, as early as 1951, who suggested scientific glass studies should conform to approaches seen in ceramic analysis, which has a much longer history of analysis. He suggested that ancient glasses should be grouped according to their chronology, method of manufacture, shape and colour, and then analysed statistically: '… on the basis of these data, samples should be selected for chemical analysis so that the results will truly represent the compositions used. This has seldom, if ever been done, so the compositions available at present can only serve as an approximate guide for future work' (Matson 1951, 86). Up to this time Roman glasses had been considered a homogeneous unit, and were analysed as a single group regardless of colour or shape. Any small compositional differences were attributed to the use of different colorants rather than changes in production methods, raw materials, economic or political organisation, or the organisation of the glass industry. Thus the amalgamation of different styles and colours in compositional analysis masked any subtle changes in composition. There was no recognition in scientific studies that the change from the strongly coloured early Roman period glasses, through colourless glasses in the late 1st to 3rd centuries, to the yellow green glasses of the 4th century may be linked to economic, social or political changes in the fabric of Roman glass production. Therefore, a more strategic sampling method was needed to move the discipline forward; a development predicted by Matson in the 1950s which was to come, but not for the next ten or twenty years.

These more holistic approaches were not immediately applied and through the 1960s and 1970s there was little development in the scientific analysis of Roman glasses except for a few studies which concentrated on the exploration of technological aspects such as colour formation, furnace conditions and unusual compositions (e.g. Rooksby 1959; Brill 1965). This was arguably because most obvious avenues of investigation such as defining composition and identifying types of raw materials for Roman glass production had been exhausted. At this time it was felt that the consistent composition through time and space gave little scope to those trying to identify patterns in the data. Rather than concentrating on why this homogeneity was so inherently *archaeologically* interesting, the chemical nature of the material was dismissed as something which would give little usable information.

New methods and theoretical approaches

A new swathe of papers relating to the scientific analysis of Roman glasses emerged in the 1980s, primarily led by researchers from CNRS in France and from the University of Bradford, UK. These papers, such as those by Sanderson, Hunter, Velde and others, came from scholars who grew up with the growth of theoretical scientific archaeology initially proposed by David Clarke (1968), where the research question becomes more clearly defined and compositional groups are sought within well-studied, securely contexted assemblages (*e.g.* Sanderson *et al.* 1984; Velde and Gendron 1980). Not only did they seek to define compositions with a greater range of elements, some down to trace levels in large data sets, they used contextual and stylistic information in conjunction with chemical data to address archaeological problems. Here were archaeologists, some trained in science, either taking the lead in scientific analysis or working symbiotically with scientists. This approach was facilitated by the use of techniques such as neutron activation analysis and X-ray fluorescence analysis, which were relatively new in archaeological research at this time; they allowed a greater number of elements to be determined, to a greater degree of sensitivity, on relatively large numbers of samples. For Roman glasses, this further refined the compositional evidence. For example, using a combination of context, date and style along with major and trace element analysis,

Sanderson *et al*. (1984) showed that Roman glasses were not compositionally homogenous through time as had previously been suggested. They concentrated on blue and green glasses which were the most prevalent in the archaeological record throughout the 2nd to 4th centuries, acknowledging that the composition was not only a feature of the raw materials used in manufacture but also displayed evidence of recycling. However, within these glasses they identified a group of later Roman and early post-Roman vessel glass which was higher in iron and manganese than the earlier glasses. They concluded that the use of different raw material resources through the Roman period, and for different glasses, was a likely explanation for these differences. This was a first step towards understanding how the Roman glass industry was organised.

By the 1990s and into the new millennium it was becoming increasingly clear that more systematic and refined methods of studying glass by chemical means were needed; that specific well-chosen archaeological questions should be formulated, the material chosen wisely, and analytical techniques used appropriately – a 'contextual' approach (e.g. Jackson *et al*. 1991; Heyworth *et al*. 1990; Mortimer and Baxter 1996). This was extending the collaborative interdisciplinary, rather than intradisciplinary, approach of archaeologists, scientists and archaeological scientists seen in the earlier work of Sanderson and Hunter. In each study, closely dated and clearly defined typological groups of vessels, or groups of glass waste from sites where glass was being manufactured or re-melted, from known contexts, were chosen. The choice of glass allowed both social and technological developments to be represented by compositional changes. Initially, it was assumed that examining waste glasses recovered from furnace sites would provide a key to identifying the provenance of glasses; however, the problems of recycling glass, alongside problems of identifying primary manufacture and re-melting at each location made any clear compositional grouping difficult. Moreover, at the few sites which were investigated, no clear compositional discrimination between manufacturing groups could be found, certainly within blue and blue-green glasses (Jackson *et al*. 1991). The only differences identified were between blue-green and colourless glasses, the latter showing lower levels of iron which indicates purer raw materials.

Other research concentrated on colourless glasses. Colourless glass forms a coherent study group because it is generally used to produce higher status objects than bluegreen glass, and changes in fashions mean that particular vessel forms have discrete and often short life-spans that can be firmly dated. It is also likely that raw materials which were free of contaminants would have been chosen, and recycling would have been more limited so the quality of the glass would be maintained. Initially these papers aimed to identify compositional patterns within or between glass styles (Jackson *et al*. 2003; Baxter *et al*. 2005) although later work concentrated on attempting to define different compositional groups which could be linked to models of production (Jackson 2005; Paynter 2006; Foster and Jackson 2010). The most obvious result from these studies indicated that colourless glasses were low in iron and other impurities associated with the sand, indeed confirming the supposition that they were produced with different, purer, raw materials than blue-green glasses. More importantly, these studies also successfully showed that within this broad 'colour' category, subtle but different compositional groups could be identified which were not based on the decolourisers antimony or manganese alone; however it proved difficult to link these compositional groups to archaeologically-identified criteria. This suggested that Roman glasses were compositionally complex, and that compositional variability occurred both between and within groups of glasses, which could not simply be explained by style, date or context, but which must be related to the organisation of production of glass (artefact production at one or more centres) within the Roman world (Jackson *et al*. 2003; Paynter 2006; Silvestri *et al*. 2008). These

results demonstrated that a model needed to be developed for glass production in the Roman world before any real understanding of the nature of the compositional information could be understood.

The search for provenance

Suddenly, it became important to re-examine the hitherto lack of a clear, definable, chemical differentiation between groups of Roman glasses, which had been a barrier to interpretation up until this point; scientists and archaeologists had been looking for compositional differences between glass groups to show that glass was made (rather than purely worked) in the small furnaces found throughout Europe and the Mediterranean. This model was one which could be proved both archaeologically and historically for later medieval glass production in Northern Europe, but was in direct contrast to that being developed for colour-specific primary glass manufacturing complexes in Bronze Age Egypt. The Roman glassmaking model had been reinforced by the wealth of small-scale furnaces excavated throughout Britain and the Mediterranean which were thought to be associated with glass production (Price and Cool 1991; Follman-Schultz 1991; Gaitzsch 1991; Foy 1991). The relative compositional homogeneity of Roman glasses to this point in time had remained unexplained, other than in terms of repeated recycling of material which was known from contemporary textual sources, and the identification of cullet at a number of furnace sites (Price and Cool 1991). The slight variations in composition were explained in terms of the use of different raw materials, in particular the sands (Sanderson *et al*. 1984), at each production location but at this point these differences could not be traced to particular vessel types or production contexts. The answer clearly lay with a better understanding of the archaeology and context of production: the chemical data could only proceed if the archaeological evidence, in the form of production sites and artefacts themselves, was revisited and other models presented as alternatives.

The breakthrough came when previously-overlooked archaeological evidence was linked directly with scientific evidence, using material which had been sitting in museums and archives throughout the Mediterranean and within Europe for many years. These were large blocks or chunks of glass which were assumed to be residues from local glass production. Their significance was realised when more of these large blocks were recovered from shipwrecks around the Mediterranean. It became clear that these glass blocks could be technologically related to large tank furnace structures (of a post-Roman date) which had only recently been published from Israel (Gorin-Rosen 1995; Nenna *et al*. 1997). These blocks of irregular shape, found with fullyformed glass vessels, suggest a trade in 'raw glass' chunks, broken from larger slabs like those produced in the large tank furnaces (Gorin-Rosen 1995). They indicate that glass formation did not necessarily take place in the same location as object manufacture, and that large 'industrial' glass slabs were probably also produced in the Roman world. Trade in 'raw glass' chunks (and ingots) suggests centralised production and distribution, such as that recorded at sites in Israel (Gorin-Rosen 2000) from the 6th century and later. However, whilst large glass factories in the Roman period have not yet been published, the movement around the Mediterranean of blocks of glass can be seen from the 1st century and earlier around (Verità 1999, 109; Foy *et al*. 2000a) and is noted as far afield as India (Stern 1991, 149), recounted in the *Periplus Maris Erythraei* (Casson 1989) written sometime around the late 1st century AD. These chunks of glass would have been remelted to produce artefacts at any number of smaller facilities throughout the Roman world and beyond. It should be noted that within the field of scientific endeavour the idea of centralised production was not a new one. As early as 1964 Sayre suggested the compositional similarity

of all Roman glass may have resulted from glass ingots being manufactured at a single site and distributed for vessel fabrication at other 'scattered locations' (Sayre 1964, 8). However, at that time the archaeological evidence to support such a theory was not available and so the idea was not pursued.

It is this latter model for Roman glass production which has been developed by most research groups in recent years. The focus of this research has been directed towards investigating the differences *and* similarities within Roman glass and the implications of this compositional data for the organisation of production: where glass was produced, where it moved for secondary working and where it was consumed. As early as the 1960s Brill (1969, 47) had suggested chemical analysis would be able to provenance glass, but for many years this had seemed unattainable. Now researchers had found a way to identify and explore, through chemical analysis, both the date and the provenance of Roman glasses. This new research takes the route of investigating the supply and procurement of glass and raw materials across the Roman world and is best illustrated by research undertaken on late Roman glass.

4th-century Roman glasses

Analyses had shown that some Roman glasses of the 4th century and later were higher in iron, titanium and manganese than Roman glasses of the 1st to 3rd centuries (Sanderson *et al*. 1984; Sanderson and Hutchings 1987; Mirti *et al*. 1993). This compositional patterning was attributed to the use of lower-grade sands for glassmaking and potentially to a different location of production.

The same pattern was picked up in 4th century 'chunks' of glass from Carthage by Freestone and co-workers (Freestone 1994; Freestone *et al*. 2002a) and by Foy and coworkers on a parallel project using raw glass blocks and vessels found in France and around the Mediterranean (Foy *et al*. 2000a; 2000b; 2003). Wedepohl *et al*. (2003) also noticed the same patterns in late Roman glasses analysed from the production site at Hambach, Germany. From these research groups two competing models of glass production began to take shape; those who believed glass was produced in large primary centres and shipped for reworking elsewhere (Freestone, Foy, Picon, Nenna and co-workers), and those who felt that the smaller glass furnaces found throughout Europe indicated a single stage production and shaping (Wedepohl and co-workers).

Both Foy *et al*. (2000a; 2000b) and Freestone (2003) showed that there were a number of different glass compositions in circulation in the Mediterranean and Northern Europe in the mid to late 1st millennium AD. From these, two main groups were identified based on major element chemistry. The first is a high iron and manganese group, seen some time before by Sanderson *et al*. (1984) and Mirti *et al*. (1993) (termed HIMT). The second is similar to earlier blue-green Roman glasses with lower levels of iron and magnesium, but has lower sodium concentrations (termed Levantine I), the differences between the groups relate to the use of different sands. These studies aimed to identify the source, or provenance, of the distinctive sands used in these glasses by trace element analysis, in particular matching the patterns of rare earth elements seen in the glasses to those of specific sand sources. The conclusion of both Foy's and Freestone's research groups suggest that the earlier, and longer-lived, low-iron Roman glasses used sands from the Syro-Palestine region, possibly, as Pliny suggests, sands from around the mouth of the River Belus, whilst the later high-iron glasses were probably manufactured using sands from Egypt, possibly from around the Nile delta (Freestone *et al*. 2005, 155), and that the glasses would have been mass produced in large tank furnaces.

These compositional analyses indicated that the suggestion of local glass production at small centres across the empire was less likely at least in Late Roman glasses (e.g. Wedepohl *et al*. 2003).

Isotope analysis was then carried out on Roman glasses in order to discover the provenance of the sands used to make the glass, by matching isotope ratios of the glasses to those from potential sand deposits. Brill had pioneered this methodological approach for glass analysis many years earlier with lead and oxygen isotopes (Brill 1970a), but because archaeological knowledge of glass production was still imperfect his findings were inconclusive. Freestone's analysis of strontium and neodymium in the high-iron glasses further supported a primary production model whereby the sand used to produce the high-iron 4th-century glasses was compatible geologically with an Egyptian origin. Moreover the isotope ratios indicated that the sand was from a relatively young volcanic source which is consistent with the sediments washed from the volcanic rocks of the Ethiopian highlands which are deposited close to the mouth of the Nile between Alexandria and Gaza (Freestone *et al*. 2005). More recent isotope studies by Degryse and Schneider (2008), Ganio *et al*. (2012) and Brems *et al*. (2013a; 2013b) suggest that for earlier 2nd and 3rd-century AD Roman glasses the origins may be indeed different from those of the 4th century.

A review of the literature shows the same two high- and low-iron glass groups in 4th- to 7th-century glasses from Rome, Carthage and glass from Sinai (Verità 1995, 300; Freestone *et al*. 2002a) and in late 4th-century glass from the north western provinces (Aerts 1998; Aerts *et al*. 1999, Foster and Jackson 2009) suggesting these compositions can be found across the Roman world. The major, trace and isotope analysis of late Roman glasses thus presents a new and better informed picture of the provenance of the raw materials, especially the sand, used to manufacture the glass, and hence points to a possible production location. These results indicate at least two major glass compositions were in circulation in northern Europe and around the Mediterranean in the 4th century, and on present evidence it is likely they were produced in the eastern Mediterranean region. The first of these, the high-iron group (HIMT), was unlike Roman glass of the preceding centuries and was made with relatively impure river delta sands, probably in Egypt. The second glass composition, Levantine I, was produced at a similar time and is thought to have been made on the Levantine coast. This recent analytical work, alongside the archaeological evidence for the movement of large glass chunks, suggests that at present the evidence points to a centralised glass production model, with primary production taking place in the eastern Mediterranean.

Early Roman Glass

Is this model of centralised production one which can be applied to earlier glass manufacture in the Roman world? The difficulties in the interpretation of colourless glass of the 1st to 3rd centuries are discussed below, but, a similar centralised model can tentatively be suggested for *highly-coloured* Roman glasses of the 1st century, where different glass colours exhibit marked differences in composition which cannot wholly be explained by the mineral additives used to produce the different hues (Jackson *et al*. 2009; Nenna and Gratuze 2009; Jackson *et al*. forthcoming). This is best illustrated by a comparison between blue, purple, colourless and amber glasses compared to the translucent emerald green and opaque red glasses, the latter two groups coloured with copper. Unlike the other glasses of this period and later, the green and red glasses are made using plant ashes for at least part of the flux, whereas the blue, purple and amber glasses are all typical of a glass made using natron/trona. The compositional consistency within these different groups indicates a production location which

is common for each colour and sometimes a group of colours, and is supported by the incidence of vivid-coloured blue 1st-century glass chunks identified in the archaeological record (Foy *et al*. 2000a). It is likely these glass chunks were coloured during manufacture at a primary location and then distributed to other locations for artefact production. Thus, as with later 4th century glasses, it appears that at least some early Roman glasses were produced in large manufacturing centres and then exported for reworking elsewhere, and that primary glass production probably took place near to raw material resources. The use of plant ashes in the production of emerald green and red glass may indicate a manufacturing complex with different traditions of manufacture, more like glass production from the early 1st millennium BC.

These approaches seek to explore where Roman glass was manufactured and how the industry was organised. Current explanations point to large centres of primary production which have yet to be discovered archaeologically. However, small differences in composition, such as those seen within the colourless glasses have yet to be fully explored, and that is the next stage of research. The investigation of primary production is advancing rapidly and allowing a greater understanding of the organisation of primary production, but this only explains part of the story of Roman glass.

Our understanding of Roman glass has historically been based on the analysis of consumption groups, where the study and analysis relate to particular vessels or groups of vessels at a site. In the model proposed for large primary production centres, the fabrication of objects is undertaken elsewhere in the Roman world, potentially nearer points of consumption. Each of these secondary fabrication centres could be supplied with glass from either a few or many different primary glass producers. Each secondary producer could produce a limited number of object types for local consumption and export, or could produce a variety of objects to furnish a local market. Thus the different compositional groups within and between vessel types certainly identified in colourless glass and probably in other types of glass, are due to the mixing of primary glasses at secondary centres. The potential combinations are many and could explain why some Roman glass vessel types can be more easily defined compositionally than others. Certainly, using predictive models will only work if we know all primary production locations, understand their glass chemistry through time, and can model this (Figs 4.1 and 4.2).

Where are we now?

Two concerns in particular have to some extent influenced studies of ancient glass composition; the analytical method used and the questions being asked of the data. Both these areas are key themes to be considered when looking at the development of studies concerned with glass composition. Techniques of analysis have changed over the years, as have theoretical concerns and archaeological questions, and this in turn has affected the nature of the investigation itself, causing a shift from one particular aspect of ancient glass composition to another.

To a degree early analytical work sought to describe the compositions of ancient glasses and research was often dictated by the analytical method used and ultimately the limitations of that method. Thus for many years Roman glass appeared to be compositionally homogenous. In the last 20 to 30 years the focus of research on Roman glass has narrowed with the development of interpretative methods that look in more depth at differences within the composition of Roman glass. Initially this interpretation was based on patterns evident

from major and minor element compositions, but more recently trace element composition and the introduction of isotope analysis have helped to determine putative provenance. The development of analytical studies has moved from the general and descriptive to the specific in terms of glass technology, and now proceeds to the integration of archaeological and scientific data to get a better understanding of the larger 'archaeological picture'. These more contextual approaches, bringing together geological, chemical and archaeological data are now taking us to a new level of understanding of Roman glass provenance and of the organisation of production of glass in the Roman world.

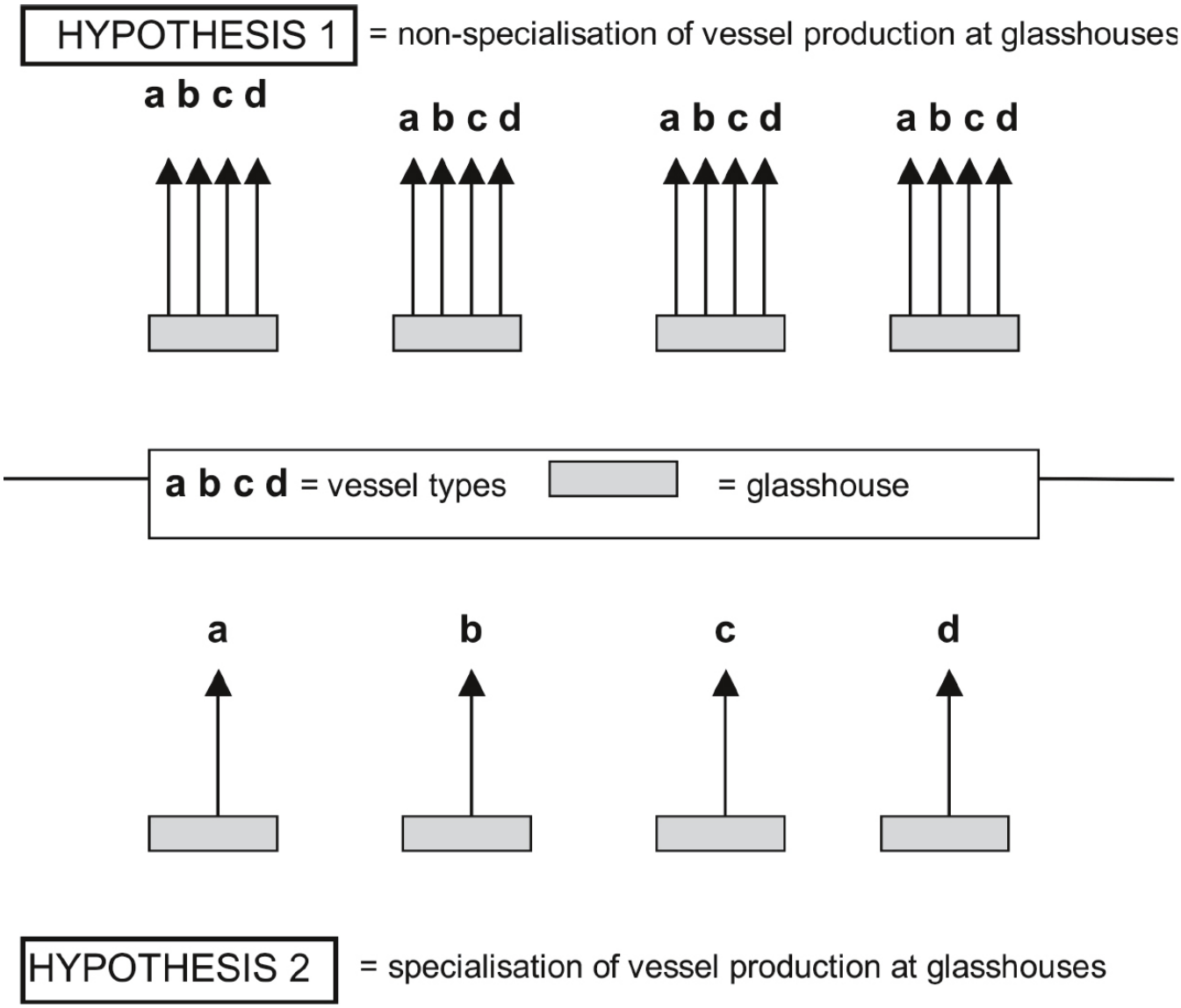

Fig. 4.1: Schematic diagram to show how glass vessel production at individual glasshouses during the Roman period may or may not have been specialised (after Foster 2004, 100).

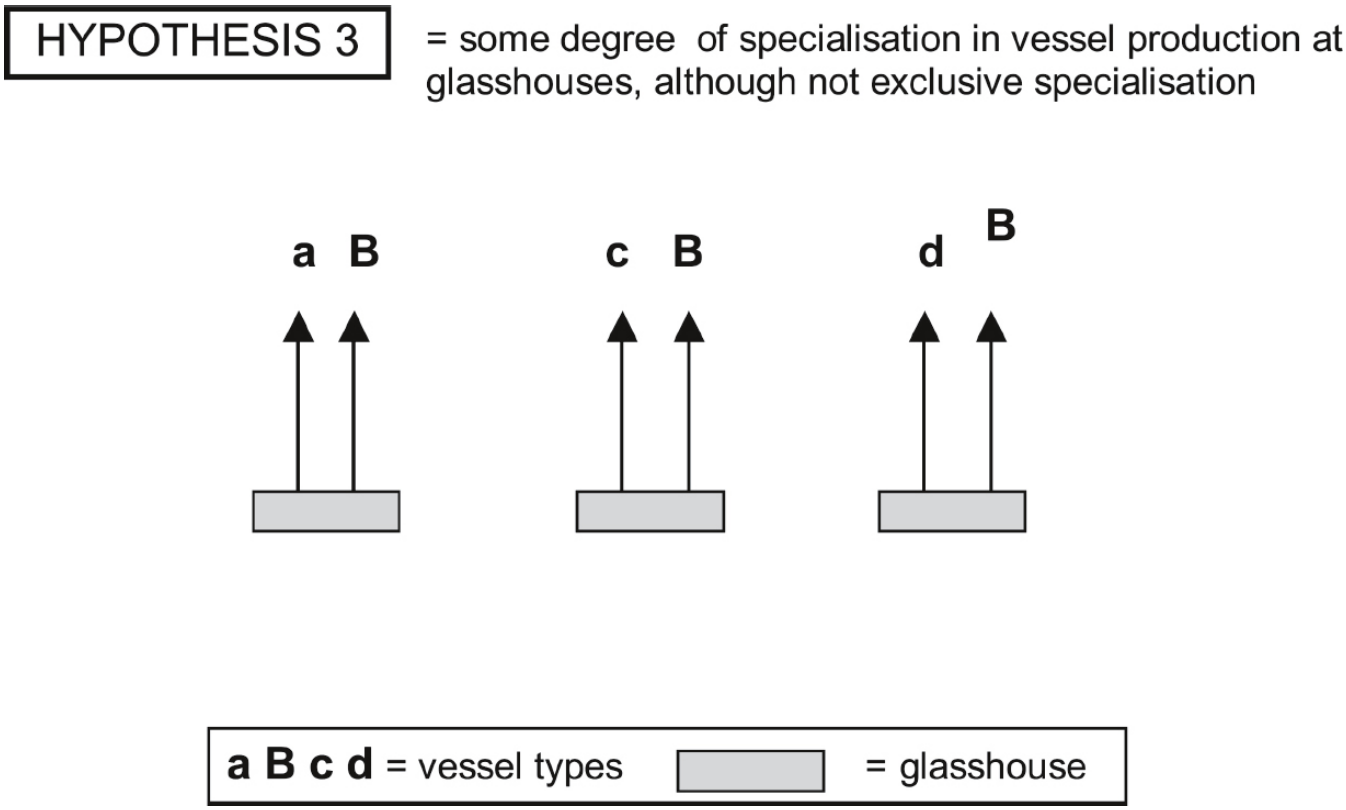
HYPOTHESIS 3
= some degree of specialisation in vessel production at glasshouses, although not exclusive specialisation
a B
c B
d B
a B c d = vessel types
= glasshouse

Fig. 4.2: Schematic diagram to show how glass vessel production at glasshouses during the Roman period may have been specialised or non-specialised according to vessel types. Here vessel B shows non-specialised production while vessels a, c and d all show specialised production (after Foster 2004, 101).

It is now possible to distinguish within the Roman period, glasses with different compositions, although the vast majority are of the soda-lime-silica tradition. It seems that these differences may have a chronological aspect, although they will also reflect other factors, such as the location of production, the organisation of the industry and/or the degree of recycling and these factors may be linked to social and political issues. For example, in the 1st century we have glasses of different colours which have been produced using completely different alkali sources; glasses within each colour group appear to have been manufactured at the same centres as they are compositionally similar. Colourless Roman glass of the 2nd and 3rd centuries is notable for its low levels of iron, phosphorus and titanium, suggesting the intentional selection of high purity sands, as well as for the presence of antimony and/or manganese at levels indicative of their deliberate addition as decolourisers. These differences are indicative of the use of different sands, and the glasses may therefore have been made at different centres. The blue-green glass that dominates most Roman assemblages from the late 1st to the 3rd centuries tends to contain higher levels of iron and other trace elements (such as the colorant copper) than does colourless glass, suggesting the use of less pure sand and the likelihood of extensive recycling. Isotope analysis of these glasses presently suggests (tentatively) that there may have been a few different production centres for these blue-green glasses and some may not have been in the Eastern Mediterranean. In the 4th century two generic compositions dominate; one contains higher levels of contaminants associated with the sand component than the other, which indicates a different manufacturing location. Trace element and isotope analysis of these later glasses have given rise to suggested production locations in Egypt and the Levant. This scientific evidence, which suggests that some late Roman glass was being manufactured in large complexes located somewhere near the coast

of Egypt, is supported by new archaeological evidence for the production of some Roman glass in specialist primary locations such as Egypt (Nenna *et al*. 2005, and this volume).

These studies have aimed to develop a model to understand more fully the organisation of production. However, an understanding of consumption assemblages is important for our understanding of Roman trade and society. Although Freestone *et al*. (2002b, 270) argued that, 'useful correlations between glass typology and composition may be unlikely where many different glass houses used raw glass made from the same raw materials' it may be possible to identify glasses with similar compositions which were fabricated at the same glass house. Indeed, more recently such an observation has been undertaken by Price *et al*. (2005) who identified a set of vessels of the same form made from a single glass batch. This interpretation is made possible if we accept that a particular glasshouse produced a repertoire of vessels by melting glass obtained from a discrete and limited number of production locations. The potential for this avenue of investigation may lie in analysing specific glass types which can be attributed to particular regions or are prized vessels or ones of high value. It is, therefore, still possible that a link can be made between different glass compositions and vessel typology, so the importance of using well-dated, typologically identifiable material for analysis is of great potential value. Present studies have concentrated on glass provenance which has proved a powerful tool for investigating the organisation of production of glass in the Roman world. However, provenance is not all; once we know more about the role of glass production in the Roman world we can investigate the economics and social history of both its production and its consumption.

Our final word must be about the debt owed to Jennifer Price whose knowledge of the place of glass in the Roman world, her encyclopaedic knowledge of the material and her faith in new work and encouragement of young (and older) minds, has contributed immeasurably to our knowledge and understanding of the history and archaeology of the Roman world.

Acknowledgements

The last acknowledgement must go to all the glass scholars who have contributed so much to our understanding of Roman glasses and their provenance who are not mentioned here in this short review article, but whose contribution is embedded in our understanding of Roman glasses.

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5

THE PONTIL IN THE ROMAN WORLD: A PRELIMINARY SURVEY

David Whitehouse†

Introduction

In his classic survey of Roman glass, Donald Harden (1969, 45–46; cf. Harden *et al*. 1987, 87) repeated the then standard opinion that the first glassblowers invented a basic tool kit that remained virtually unchanged for almost two millennia. The essential components of the kit were believed to be the blowpipe, pontil, jacks, shears, and marver.

Thanks largely to the researches of Marianne Stern, we know now that this assumption was false. Stern (1999, 448–450) discussed the evidence for the blowpipe and the pontil. In a nutshell, she demonstrated that while some form of blowpipe is, of course, essential for glassblowing, the pontil is not; other methods exist to hold an object in order to reheat the rim and finish it. Subsequently, she turned her attention to the jacks and the shears (Stern 2002). She noted that shears with two parallel blades connected by a curved spring were already known in north-western Europe in the mid 1st millennium BC, and they were used for shearing sheep in parts of the Mediterranean two or three hundred years later; jacks, therefore, which also have two blades connected by a spring, could have been part of the original glassblower's tool kit. Indeed, the form of the mouths and constrictions at the base of the neck of numerous 1st-century (and later) glass vessels are most easily explained by manipulation with jacks, although William Gudenrath dispensed with jacks when he made replicas of the Portland Vase blank in 1988–9 (Gudenrath and Whitehouse 1990, 110–115). Shears, on the other hand, which have two crossmounted blades moving on a pivot, do not appear to have been common in the Roman world in the early centuries AD and Stern noted that Roman glass vessels do not exhibit the kind of marks – clean-cut handle attachments, for example – that are produced by shears. Today, therefore, we know that glassblowing was made possible by the discovery that a mass of molten glass could be formed into an object by blowing air into it through a tube; and we believe that jacks were an early addition to the glassblower's tool kit but that shears were not employed in the Roman period.

The pontil and pontil marks

This paper, which I offer to Jenny with affection and respect, is a small contribution to our knowledge of the use of another supposed component of the basic tool kit of Roman glass

workers – the pontil. It is based primarily on a survey of the presence or absence of pontil marks (hereafter, marks) on 621 of the Roman and early post-Roman blown glass objects in The Corning Museum of Glass, which are published in the Museum's three-volume catalogue of Roman glass (Whitehouse 1997, 2001, 2003: hereafter, the catalogue). For obvious reasons, the survey does not include fragments from parts of objects, such as rims, where one would not expect to find a pontil mark, objects on which cold working has removed the evidence for or against the existence of a mark, undatable objects, and objects of questionable authenticity. For the purposes of this paper I have assumed that the identifications and dates proposed in the catalogue are correct.

Needless to say, the sample is flawed. Almost all the objects were acquired in the marketplace and very few of them have even regional provenances. They are identified, therefore, on the basis of parallels from known find-places and datable contexts. Some regions and periods are well represented in the sample, while others are absent. The catalogue is more successful at suggesting dates for objects than identifying where they may have been made. Nevertheless, the collection is a point of departure and I hope that others will supplement or correct my observations by adding information from other sources.

The most obvious observation is how often there is no trace of a mark. On 379 of the 621 Roman blown glass objects in the sample (61 percent) there is no mark. The numbers include objects with cracked-off rims, which were not finished by hot working and so did not require holding on a pontil or in some other tool; but, even when we subtract these pieces, the figures are impressive: 271 objects in a sample of 513 (53 percent) do not have a mark. It is noteworthy that the rims of large cinerary urns (Isings 1957, forms 63 and 65) and very large, heavy cylindrical bottles (Isings form 51), some of which are more than 400mm high, were finished at the furnace without holding them on a pontil. The Romans, therefore, sometimes used tools other than pontils to hold objects for reheating and finishing; perhaps they were similar to the clamps or snaps used in 19th-century glass working.

The vessels with hot-worked rims but no pontil marks are varied and they include objects of every century between the years one and 700: 117 (43 percent) are 1st-century, 45 (17 percent) are 2nd- to 3rd-century, 77 (28 percent) are 3rd- to 4th-century, and 29 (11 percent) are 4th-century or later. This is consistent with the archaeological evidence that vessels with marks appeared first, for example, at Augst/Kaiseraugst about the middle of the 1st century (Rütti 1991, 64) and at Avenches between about 40 and 70 (Amrein 2001, 80–81), and with Stern's (1995, 43–44) statement that the collection of The Toledo Museum of Art does not contain a single mark that is earlier than the second half of the 1st century. If, for this reason, we subtract all 1st-century objects from the Corning sample, the total of objects without marks is reduced to 262, of which 30 percent were made in the 2nd to 3rd century, 51 percent in the 3rd to 4th century and 19 percent in and after the 4th century. Apparently, by the 5th century it had become more usual to use a pontil.

Classification of marks

The marks on the bases of Roman objects at Corning fall into three groups: a ring of small scars, each of which is separated from its neighbours; a more or less continuous annular scar; and a solid circular or sub-circular scar. The first type is rare (it accounts for less than 0.5 percent of the marks recorded in the survey). The second, annular type is uncommon on the glass at Corning (it represents less than 6 percent of all the marks); it may have been made by using a blowpipe but this is not necessarily the case. The third type, which varies in shape from an almost perfectly circular solid scar to an irregular part of a solid circle, is by far the most common (94 percent) and it resembles the marks left by modern pontils.

In the following, I will focus on the three largest categories of Roman blown glass in the collection at Corning: objects with no decoration, objects with applied decoration and objects with mould-blown decoration.

Undecorated objects

Corning has 252 undecorated objects with hot-worked rims and visible bases, of which only 104 have marks. Of these, 67 (64 percent) have solid marks, at least 22 (21 percent) have annular marks and three (3 percent) have rings of unconnected scars. The solid marks occur on vessels of all periods after the mid to late 1st century.

On the other hand, with five exceptions, the annular marks at Corning occur on vessels made in the mid or later 1st century, or at some undetermined date between the 1st and the 4th centuries. Five out of 13 hemispherical cups with a folded tubular flange and a tubular foot ring (Isings form 69a) have annular marks. Two of the later annular marks date from the 2nd or 3rd centuries and two are 5th or 6th century (both occur on objects similar to vessels found at Karanis; for the chronology of the site see Whitehouse 1999).

The ring of small scars occurs on only three objects, all of which are 1st-century dishes similar to Dragendorff's red slipware forms 17 and 23. Glass dishes of this type are common at Pompeii and Herculaneum, and their occurrence at these sites shows that they were already in use in 79 (see Whitehouse 1997, 68, no 77 for a list of finds from datable archaeological contexts). A cursory inspection of the glass exhibited in the Museo Archeologico Nazionale in Naples suggests that a ring of small scars may have been a common mark on vessels used around the Bay of Naples in or shortly before the third quarter of the 1st century. I have not noted its occurrence anywhere on ancient glass objects later than the 1st century, and perhaps we can assume that it represents a technique of holding the vessel that was used partly or mostly in Italy and for only a short period.

Objects with applied decoration

The second large category of blown glass at Corning consists of objects with applied decoration. The catalogue contains 182 vessels. Six of these are *zarte Rippenschälen* with cracked-off rims and 45 are fragments or appliqués, leaving 131 objects with hot-worked rims and surviving bases. Most of these objects are late. Only 21 (16 percent) are attributed to the 1st or 1st to 2nd centuries, while 110 (84 percent) are 2nd to 3rd century or later. Sixteen of the 1st- or 1st- to 2nd-century vessels have no mark, three have annular marks and one has a solid mark.

The pattern changes when we consider the later vessels. Twenty objects (18 percent) have no mark, three have annular marks and 87 (79 percent) have solid marks. All of the snake thread vessels have solid marks, as do 12 cosmetic tubes (no mark appears on two other tubes).

Objects with mould-blown decoration

Finally, I come to vessels with mould-blown decoration. I shall comment on three groups: early to mid 1st-century objects, mostly of the so-called 'Sidonian' type; late 1st- to 3rd-century 'Mercury flasks' and other mould-blown bottles; and 6th- to 7th-century vessels decorated with Christian or Jewish symbols. One might assume that none of these objects have pontil marks; but this is not the case.

The 1st-century objects include small cylindrical and hexagonal bottles, various other bottles, pitchers and *amphoriskoi*, and objects from the 'Workshop of the Floating Handles'. Most – possibly all – of them were made in the Syro-Palestinian region. Corning has 20 such vessels with hot-worked rims. None of these objects – not even a large pitcher with decoration

imitating a design used by Ennion – has a mark. This is consistent with the view that the pontil was not used before the mid-1st century.

Corning has 40 complete or fragmentary late-1st- to 3rd-century Mercury flasks and other mould-blown bottles with inscribed bases. All but three of these objects were once in the Sangiorgi Collection, which was formed in Rome, and so we may be looking at a type that was very common in Italy. None of the seven complete 2nd- to 3rd-century Mercury flasks, all of which have hot-worked rims, have marks, nor do any of the 13 fragmentary bases. Indeed, the only objects with marks are the base of a large bottle, attributed to the late 1st or 2nd century, an eight-sided bottle with a Greek inscription and a Frontinus bottle, all of which have annular marks.

The 6th- to 7th-century vessels with Christian or Jewish symbols, and related objects, are believed to have been made in Jerusalem and at other places in the Levant. They are represented at Corning by 12 objects, all of which have solid marks. The collection at Toledo is larger (23 objects). Every vessel at Toledo has a mark and, to judge from the published descriptions, 19 of these marks are definitely solid and four may be annular (Stern 1995, 247–265). At the Yale University Art Gallery, again judging from published descriptions, 10 of the 13 similar objects have undefined marks and neither the presence nor the absence of a mark was noted on the other three (Matheson 1980, 129–138). All four vessels of this type in the Wolf Collection have solid marks (Stern 2001, 274–275, 322–328). Thus, of the 52 examples just noted, 45 (85 percent) have solid marks, 4 (8 percent) are described as having annular marks and we have no information about the other three. It seems reasonable to conclude that the great majority of 6th- to 7th-century mould-blown objects from the Levant have solid marks.

Some tentative conclusions

The Corning sample suggests that it might be useful to test the following ideas by examining glass in other collections, and in particular glass from datable contexts in known find-places:

- Since only 21 of 138 1st-centuy objects have marks, it seems clear, as Stern observed, that the pontil was not part of the early glassblower's tool kit. Indeed, it may have come into use only in or about the third quarter of the 1st century. Before its introduction, presumably some form of clamp was employed to hold blown objects while their rims were reheated for finishing.
- Marks consisting of a ring of small, unconnected scars may belong exclusively to the 1st century.
- Annular marks are relatively uncommon (they account for only 21 percent of the marks at Corning). Ten of the annular marks at Corning (29 percent) are datable to the 1st century, after which their occurrence is sporadic. This, of course, may be due to the uneven character of the collection.
- In all periods after the 1st century, solid marks are by far the most common evidence of the use of pontils, although (as we have seen) rims were frequently hot-worked without the aid of a pontil.

These observations lead me to suggest that the third quarter (or second half) of the 1st century may have been a time of experimentation with methods of holding the bottoms of objects whose rims were finished at the furnace. Clamps seem to have been employed before the pontil became the tool of choice, although the clamp was never abandoned. However, in

the Corning collection, in and after the 4th century, 65 percent of all vessels with hot-worked rims were held on a pontil and only 35 percent in a clamp or some other device.

If I may conclude with one further suggestion, it is that someone should examine the hundreds of blown glass vessels from Pompeii and Herculaneum preserved in the Museo Archeologico Nazionale in Naples and in the site museums, and determine precisely how the glassware used in these cities in and before 79 was finished at the mouth of the furnace. It is just possible that the eruption of Vesuvius happened at about the right time to allow us to investigate a formative stage in the evolution of the Roman glass industry: the moment when the pontil became a standard tool for holding vessels in order to hot-work the mouth.

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6

COMPOSITION, TECHNOLOGY AND PRODUCTION OF COLOURED GLASSES FROM ROMAN MOSAIC VESSELS

Ian C. Freestone and Colleen P. Stapleton

Introduction

Profound changes occurred in the early Roman glass industry, which included a major increase in the scale of production along with the widespread adoption of shaping by blowing a gather of hot glass on a blowpipe (*e.g.* Grose 1986). However, our understanding of the detail of these changes remains limited. It might be expected that the substantial reorganisation of the industry that occurred at that time would have had ramifications for the technologies used to produce the glass materials used in vessel production and by implication their compositions. However, the number of published datasets of compositions of early Roman glass is surprisingly small and although we have a general understanding of the colourants used in Roman glass, we have limited understanding of any variations in craft practice that may have occurred with time and place.

The subject of the present paper is the opaque and strongly coloured glass used to manufacture polychrome mosaic glass vessels in the early imperial period, from the 1st century BC to the 1st century AD (Fig. 6.1). The forms of these early Roman vessels are in general very similar to those of the Hellenistic world, and it seems likely that Hellenistic glassworking skills were transmitted to the Roman glass industry (Grose 1989). There is little direct archaeological evidence for the location of the workshops involved in the production of these vessels, but literary evidence suggests that a major source of coloured glass vessels at this time was Rome itself (Grose 1986; 1989) and the distribution of the objects from archaeological contexts supports this view (Nenna 2002).

Mosaic glass vessels are generally believed to have been made using a technique known as slumping, whereby a disc formed from slices of coloured canes was slumped over a domed form to produce an open vessel, typically a bowl (Figs 6.2, 6.3; Grose 1986; Gudenrath 1991; Taylor and Hill 2003). The complex *chaîne opératoire* and high level of skill that would have been required to produce the bowls suggest that they were relatively expensive items and a number of writers of the mid-1st century AD comment that, by that time, glass had recently become much less expensive, implying that the earlier vessels of the type under discussion here were costly (Grose 1986).

The use of strongly-coloured vessel glass declined dramatically in the 1st century AD, with the adoption of glass-blowing as a means of fabrication, which favoured the adoption of transparent colourless and naturally coloured glass for utilitarian purposes. Colourless glass

resembling rock crystal had, according to Pliny (*Natural History* books 34–37: Eicholz 1962), become the most expensive variety of glass. This change in the use of colour in glass vessels did not necessarily mean a decline in the production of strongly coloured glass, however. Although it became far less frequent in vessels, the use of coloured and opaque glass continued as an important element of the wall mosaics which decorated the houses of the wealthy. Thus while glass as a material became accessible to a much wider stratum of society than had previously been the case, strongly coloured glass is likely to have continued to occupy a niche at the upper end of the market, a necessity as its production is likely to have been a relatively expensive affair, in terms of both time and raw materials.

In this paper, analyses of a range of colours from two types of early Imperial Roman mosaic vessels are presented and used to interpret the colourant technology. These are compared to the compositions of other Roman glassware to identify any variations in technology that may have taken place. A major wide-ranging analytical survey of mosaic vessel glass by Nenna and Gratuze (2009) is underway. However, as will be shown here and has been argued elsewhere, detailed examination of closely related groups of material can yield information which complements that of more general surveys (cf. Price *et al*. 2005; Freestone *et al*. 2009).

Fig. 6.1: Mosaic glass bowl with applied foot. 25 BC-25 AD. Victoria and Albert Museum 969–1868.

Analysed vessels

The origins of the mosaic glass fragments of this study are described by Stapleton (2003). The fragments are divided into two stylistic groups based on colour patterns. Three fragments derived from ribbed bowls on tall foot rings in the collections of the British Museum (BM), consist of marbled white opaque with blue transparent or amber (brown) transparent glasses (vessel nos. 11–13; Fig. 6.4). The second group, from the collections of the Victoria and Albert Museum (VA), are formed of short strips of coloured canes from unidentified vessel forms (vessels 2–9; *e.g.* Fig. 6.5). The colours of these vessels include those found in the marbled fragments as well as opaque red and yellow, and translucent pale blue, purple and colourless. In these fragments, glass that appears to be translucent green in fact comprises a transparent pale blue glass overlying an opaque yellow glass. Table 6.1 shows the concordance between the analysis numbers and the museum registration numbers.

Analytical Methods

Forty-nine individual samples of coloured and colourless glass, less than $2mm^3$, were removed from 10 vessel fragments, representing nine colours overall. The elemental compositions of the samples were analysed in a JEOL JSM 840 scanning electron microscope (SEM) using an Oxford Instruments Link ISIS energy dispersive X-ray analyser (EDXA) with a GEM germanium detector. The glasses were analysed at 15 kV accelerating voltage, and 1.7 nA beam current measured in a Faraday cup, for 200 seconds. The electron beam was rastered over as large an area as possible that avoided weathered or otherwise altered glass. In this way the area analysed represented as closely as possible the relative proportions of opacifier and glass matrix. All analyses are presented as weight percent. Detection limits are around 0.1% for each oxide, except for SnO_2 and Sb_2O_3 which are around 0.4%. Pure oxides, elements and minerals were used as primary standards. Corning Glass standards A, B, C, and D (Brill 1999) as well as commercially available glass standards were used as secondary standards and were routinely analysed. On this basis, the accuracy relative to the standards for elements present in concentrations above 10% is around 1%; for elements present between 1% and 10% is better than 5%; and better than 20% for components present between 0.3% and 1%, except for sulphur, which has a relative accuracy of about 100%.

Fig. 6.2: Stages in the production of mosaic glass vessels, produced by Mark Taylor and David Hill – canes, sliced canes, disc ready for slumping, former and glass bowls.

Fig. 6.3: Slumping of a glass disc over a bowl-shaped former. Replication by Mark Taylor and David Hill.

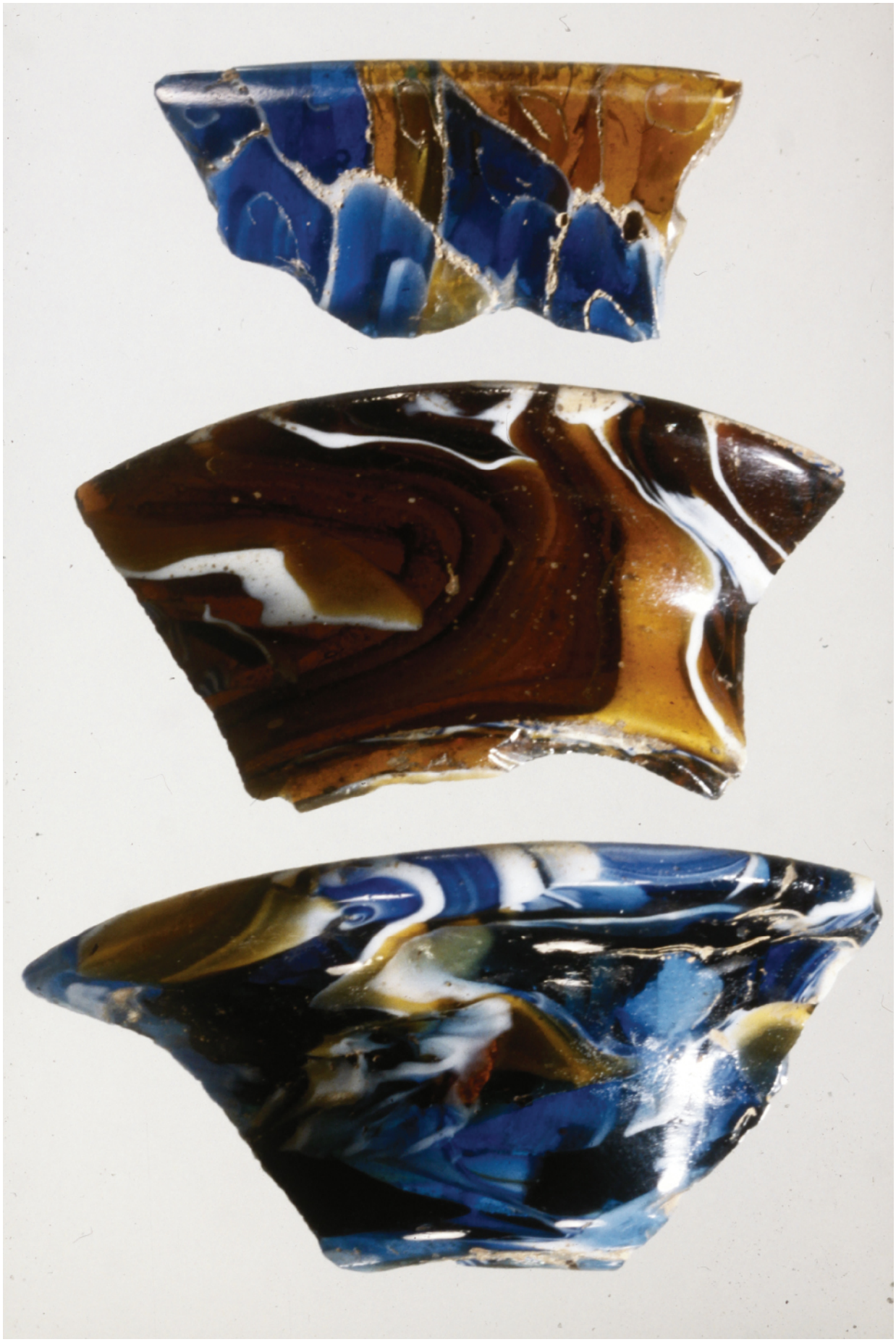

Fig. 6.4: The marbled fragments investigated, British Museum (see text). Photo: British Museum

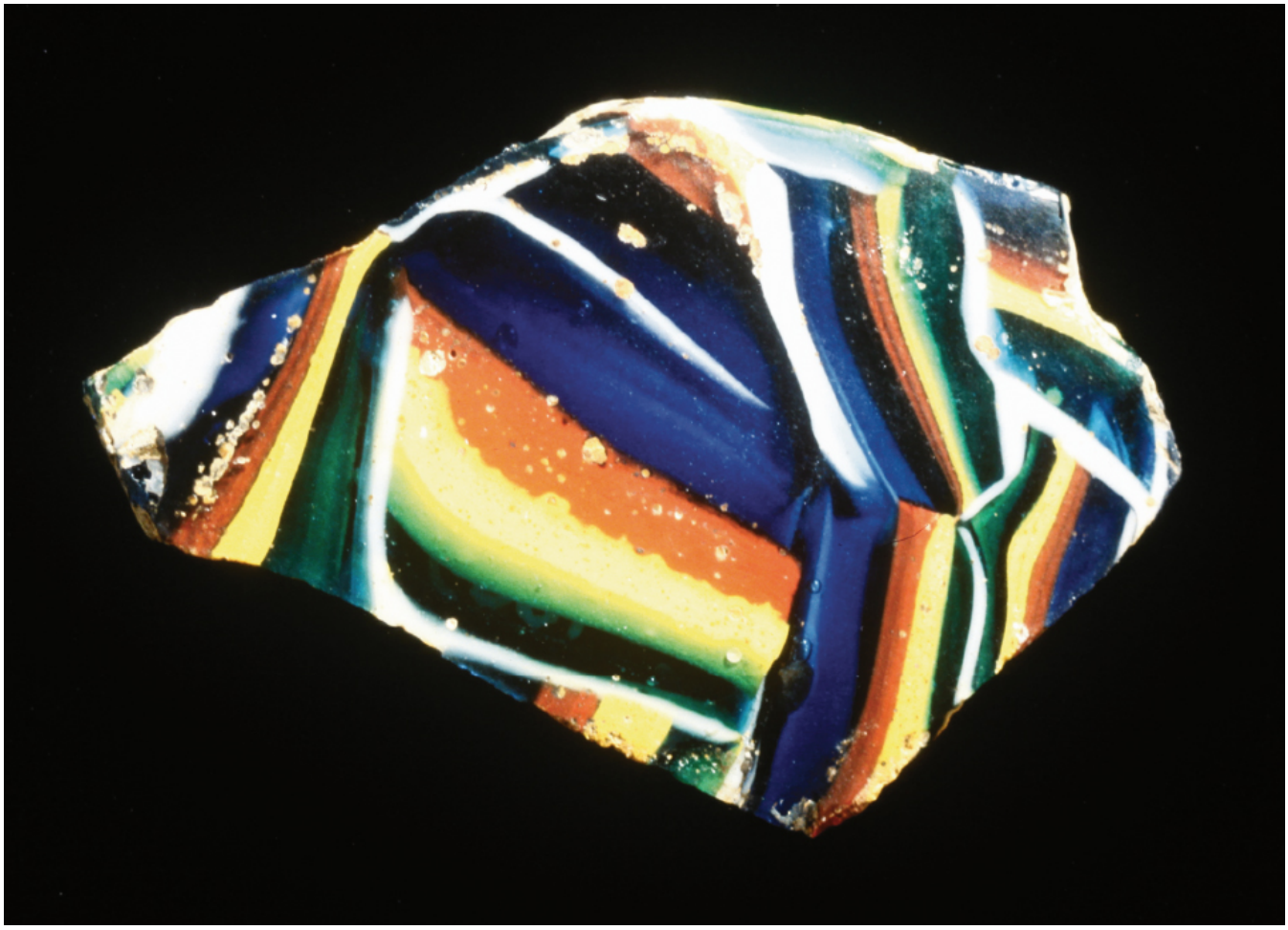

Fig. 6.5: A fragment from a bowl composed of coloured strips. Victoria and Albert Museum (see text). Photo: British Museum

Vessel no.	*Museum reg. no.*
3	VA 63/1 63/20 63/2 - 1883
4	none (VA)
5	VA 63/12:16 - 1885
6	VA 63/1 63/20 63/12 - 1885
7	VA 63/1 63/20 63/12 - 1885
8	VA 63/1 63/20 63/12 - 1885
9	VA 63/1 63/20 63/12 - 1885
11	BM GR 1886,11-17,203
12	BM GR 1886,11-17,252
13	BM GR 1886,11-17,252

Table 6.1: Concordance of Museum number and analytical number.

In addition, using the approach of Verità *et al*. (1994), transparent pale blue, transparent medium to dark blue, opaque medium blue and purple, and colourless glasses, were analysed a second time at 40 kV with 0.6 nA current for 200 seconds. The increased sensitivity offered by the higher excitation potential allowed improved detection limits of 0.05% for cobalt and zinc, 0.07% for copper, and 0.2% for tin and antimony. Relative accuracies for these elements are the same as for those analysed at 15 kV. Elements present in the opacifying phases in the glass were identified by spot analysis.

Results

SEM-EDXA results are listed by colour in Table 6.2. In addition to the absolute compositions given in the Table, the compositions of the glasses were also considered as reduced compositions (Brill 1999) including only SiO_2, Al_2O_3, MgO, CaO, Na_2O, K_2O, P_2O_5, SO_3, and Cl, components brought into the glass mainly through the batch raw materials rather than as

colourants. This allows comparison of the base glasses without the diluting effects of added colourants and opacifiers, which range up to 35% in the case of lead oxide, for example.

The base glasses are all soda-lime-silica glasses. The majority have characteristic "Roman" compositions insofar as they have magnesia and potash below 1.5%, indicating that they were made using natron as a source of soda, rather than plant ash (Brill 1970; Lilyquist and Brill 1993). In the reduced compositions, lime is typically around 8% in most glasses, while soda is around 18%. Alumina is typically 2.5% and is substantially higher only in some opaque yellow and red glasses. Except in the opaque yellow, red and dark blue glasses, iron oxide is typically 0.3–0.4% and these values are considered typical of the sand from which the glass was made, as similar values are also characteristic of later Roman-type glass from primary glassmaking furnaces (*e.g*. Freestone *et al*. 2000). Manganese, well known as a decolourant in Roman glass (Sayre 1963; Jackson 2005), was detected in most glasses except the ambers, its concentration varying typically between 0.2 and 1.4%. These characteristics are not exceptional in a Roman context. We therefore infer that all of the coloured glasses presently analysed, with the possible exception of some of the opaque reds, were made from a natron-type soda-lime-silica base glass with about 0.4% FeO, which in most cases had already been decoloured by variable amounts of manganese oxide. The various colouring and opacifying agents are likely to have been added to such a base glass.

Colourless, purple and amber glasses

The colours of these transparent to translucent glasses depend largely upon the behaviours and interactions of the elements iron, manganese and antimony. Their influence upon the colour of Roman glass has been usefully discussed by Schreurs and Brill (1984) and more recently by Bingham and Jackson (2008). Without a deliberately-added colourant, such as copper or cobalt (see below), the colour of glass depends largely upon the amount and oxidation state of any iron present. The ferrous ion, Fe^{2+}, formed under reducing conditions, is responsible for a distinctive bluish colouration, while the oxidised ferric ion, Fe^{3+}, is responsible for a much less intense yellow. Most glasses contain iron in both oxidation states, generating a range of greens, bluish greens and blues.

Sayre (1963), in a seminal study, recognised that manganese and antimony oxides were added deliberately to some ancient glass as decolourants, to convert the relatively strong blue-green colour of Fe^{2+} to the weak yellow of Fe^{3+} and change a relatively intense bluish tint to a hardly noticeable yellow. The detailed mechanisms involved are complex; the initial role of the compounds MnO_2 and Sb_2O_5 was probably to add oxygen to the melt but, once dissolved, the manganese and antimony cations form redox couples with iron, helping to maintain its oxidised condition (Schreiber *et al*., 1999; Pollard and Heron 2008). There is some confusion in the literature over the level of manganese in a glass which indicates a deliberate addition. However, in natron glasses, negligible manganese will have entered the glass with the alkali, and any levels above those natural to sand are likely to reflect a deliberate addition at some point in the glassmaking process. The ratio iron:manganese in the earth's crust is around 10:1 (Wedepohl 1995; Kamber *et al*. 2005) and appears not to depart significantly from this in most glassmaking sands. Iron concentrations in most vessel glass are around 0.5% (5000 ppm), implying that manganese below 500 ppm is derived from the sand but that higher levels reflect additions by the glassmakers. This view is supported by the analysis of raw glass from the Byzantine and early Islamic primary tank furnaces where manganese concentrations are typically a few hundred ppm (Freestone *et al*. 2000 and unpublished data). Similarly, antimony levels in sand are typically at the ppm (or sub-ppm) level, and greater concentrations will indicate the addition of an antimony-bearing ingredient. Hence antimony

and manganese oxides detectable by the SEM-EDXA techniques used in the present study are likely to represent deliberate additions at some stage in the production process, with the proviso that in some cases they may have been incorporated by the recycling of old glass.

Vessel no.	SiO_2	TiO_2	Al_2O_3	*FeO*	*MnO*	*MgO*	*CaO*	Na_2O	K_2O	P_2O_5	*Cl*	SO_3	*CoO*	*CuO*	*ZnO*	SnO_2	Sb_2O_3	*PbO*	*Total*
translucent pale blue																			
4	66.62	<0.10	2.40	0.39	0.18	0.44	7.65	18.17	0.56	0.17	0.91	0.78	<0.04	1.41	<0.05	<0.20	<0.20	0.17	99.85
5	68.32	<0.10	2.25	0.23	0.49	0.43	7.19	18.16	0.79	<0.10	0.42	1.00	<0.04	1.59	<0.05	0.29	<0.20	0.25	101.41
6	66.99	<0.10	2.51	0.36	0.54	0.52	7.26	17.49	0.74	0.16	1.00	0.57	<0.04	1.53	<0.05	0.33	0.25	0.28	100.53
8	64.38	<0.10	2.01	0.28	0.82	0.59	8.01	18.38	0.56	<0.10	1.00	0.41	<0.04	1.77	<0.05	0.29	0.30	0.43	99.23
9	65.26	<0.10	2.16	0.29	0.41	0.65	8.07	17.98	0.68	0.12	0.81	0.43	<0.04	1.86	<0.05	0.32	0.34	0.25	99.63
translucent medium to dark blue																			
3	65.84	<0.10	2.42	1.12	1.22	0.67	8.26	18.09	0.82	0.23	0.80	0.42	0.09	0.14	<0.05	<0.20	<0.20	<0.10	100.12
4	66.87	<0.10	2.60	1.39	0.32	0.56	7.85	18.31	0.81	0.11	0.58	0.48	0.15	0.17	0.33	<0.20	<0.20	<0.10	100.53
6	66.61	<0.10	2.44	1.33	1.03	0.63	7.88	17.67	0.83	0.16	0.88	0.39	<0.04	0.12	<0.05	<0.20	0.34	<0.10	100.31
7	66.45	<0.10	2.40	1.30	0.99	0.68	7.81	17.82	0.83	0.17	0.80	0.41	0.07	0.11	<0.05	<0.20	0.39	<0.10	100.23
8	67.17	0.16	2.42	1.67	0.38	0.63	8.89	18.79	0.81	0.27	0.70	0.42	0.11	0.13	<0.05	<0.20	0.33	<0.10	102.88
9	65.29	<0.10	2.34	1.39	0.99	0.59	8.69	17.84	0.85	0.15	0.63	0.47	0.11	0.53	0.53	<0.20	0.42	<0.10	100.82
11	67.78	<0.10	2.48	0.91	0.45	0.48	7.60	17.54	0.77	<0.10	0.88	0.44	<0.04	0.05	<0.05	<0.20	<0.20	<0.10	99.38
12	67.66	<0.10	2.34	0.87	0.28	0.59	9.18	16.80	0.57	0.14	0.60	0.67	0.05	0.19	<0.05	<0.20	<0.20	<0.10	99.94
opaque medium blue																			
13	60.42	<0.10	2.21	1.77	0.92	0.54	7.71	15.00	0.68	0.16	0.53	0.80	0.91	0.44	<0.10	<0.40	6.80	<0.10	98.89
colourless																			
3	65.56	<0.10	2.33	0.28	2.66	0.69	7.44	18.81	0.59	0.12	1.05	0.50	<0.10	<0.10	<0.10	<0.40	<0.30	<0.10	100.03
5	67.24	<0.10	2.60	0.34	1.33	0.60	7.96	18.81	0.80	0.11	1.00	0.41	<0.10	<0.10	<0.10	<0.40	<0.20	<0.10	101.20
6	66.52	<0.10	2.73	0.37	1.42	0.66	7.62	18.43	0.84	0.15	1.00	0.35	<0.10	<0.10	<0.10	<0.40	<0.20	<0.10	100.09
7	68.51	<0.10	2.24	0.23	1.07	0.56	7.29	17.73	0.75	<0.10	0.76	0.48	<0.10	<0.10	<0.10	<0.40	<0.30	<0.10	99.62
8	68.30	<0.10	2.40	0.33	1.24	0.63	8.83	18.76	0.69	0.18	0.90	0.48	<0.10	<0.10	<0.10	<0.40	<0.20	<0.10	102.74
9	66.55	<0.10	2.29	0.35	1.18	0.60	7.42	19.13	0.70	<0.10	0.76	0.60	<0.10	<0.10	<0.10	<0.40	<0.40	<0.10	99.58
translucent purple																			
4	64.18	<0.10	2.54	1.10	3.05	0.78	8.66	17.54	0.77	<0.10	0.61	0.47	<0.04	0.22	<0.05	<0.20	0.25	<0.10	100.17
8	68.71	<0.10	2.16	0.34	1.41	0.62	8.03	19.08	0.65	0.11	1.09	0.39	<0.04	<0.06	<0.05	<0.20	0.26	<0.10	102.85
9	67.61	<0.10	2.10	0.30	1.61	0.57	7.89	18.64	0.64	<0.10	1.04	0.33	<0.04	<0.06	<0.05	<0.20	0.37	<0.10	101.10
translucent amber																			
8	70.13	<0.10	2.36	0.26	<0.10	0.45	7.35	19.20	0.73	<0.10	1.08	0.37	<0.10	<0.10	<0.10	<0.40	<0.20	<0.10	101.93
11	66.98	<0.10	2.32	0.19	<0.10	0.40	7.03	16.43	0.77	<0.10	0.95	0.56	<0.10	<0.10	<0.10	<0.40	<0.40	<0.10	95.63
12	70.51	<0.10	2.49	0.26	<0.10	0.39	7.23	17.06	0.64	<0.10	1.22	0.35	<0.10	<0.10	<0.10	<0.40	<0.40	<0.10	100.15
13	69.40	<0.10	2.58	0.26	<0.10	0.52	7.49	17.31	0.81	<0.10	1.17	0.27	<0.10	<0.10	<0.10	<0.40	<0.40	<0.10	99.81
translucent black																			
12	68.33	<0.10	2.69	0.76	0.27	0.54	9.29	10.55	0.64	0.29	1.17	1.21	<0.10	1.56	<0.10	<0.40	<0.40	<0.10	97.30
opaque white																			
3	62.26	<0.10	2.27	0.34	1.27	0.69	7.54	15.83	0.83	0.20	0.45	0.89	<0.10	<0.10	<0.10	<0.40	7.68	<0.10	100.25
4	65.03	<0.10	2.42	0.37	0.36	0.58	7.82	16.87	0.81	0.16	0.54	0.73	<0.10	<0.10	<0.10	<0.40	4.22	<0.10	99.91
4	57.14	<0.10	2.05	0.39	0.79	0.66	6.81	13.88	0.71	<0.10	0.45	0.58	<0.10	<0.10	<0.10	<0.40	3.86	12.05	99.37
5	64.75	<0.10	2.24	0.33	0.40	0.50	7.12	16.66	0.74	<0.10	0.45	0.93	<0.10	0.34	<0.10	<0.40	6.49	<0.10	100.95
6	62.97	<0.10	2.30	0.35	1.17	0.74	7.79	16.55	0.74	0.12	0.50	0.85	<0.10	<0.10	<0.10	<0.40	6.11	<0.10	100.19
7	63.90	<0.10	2.20	0.35	0.80	0.74	6.99	15.57	0.85	0.14	0.46	0.67	<0.10	<0.10	<0.10	<0.40	6.85	<0.10	99.52
8	65.30	0.15	2.40	0.35	0.53	0.56	8.39	17.34	0.77	0.12	0.51	0.77	<0.10	<0.10	<0.10	<0.40	5.03	<0.10	102.22
9	53.45	<0.10	1.85	0.37	0.93	0.59	6.32	12.64	0.57	<0.10	0.29	0.63	<0.10	<0.10	<0.10	<0.40	6.61	15.51	99.76
11	64.02	<0.10	2.40	0.38	0.37	0.58	7.57	14.82	0.72	0.11	0.50	0.85	<0.10	<0.10	<0.10	<0.40	6.14	<0.10	98.46
12	64.24	<0.10	2.38	0.28	0.66	0.54	6.72	15.75	0.64	0.15	0.42	0.79	<0.10	<0.10	<0.10	<0.40	7.37	<0.10	99.94
13	61.94	<0.10	2.50	0.53	1.07	0.68	7.08	15.74	0.80	<0.10	0.50	0.95	<0.10	<0.10	<0.10	<0.40	7.35	<0.10	99.14
opaque yellow																			
3	45.76	<0.10	1.93	1.63	0.44	0.48	3.76	9.73	0.46	<0.10	0.55	0.35	<0.10	<0.10	<0.10	<0.40	2.98	31.98	100.05
5	47.17	<0.10	1.70	1.41	<0.10	0.41	4.66	9.79	0.50	<0.10	0.58	0.80	<0.10	<0.10	<0.10	<0.40	2.16	30.25	99.43
6	42.64	<0.10	1.81	1.30	<0.10	0.33	3.47	11.23	0.43	<0.10	0.57	0.56	<0.10	0.37	<0.10	<0.40	3.58	33.40	99.69
7	47.58	0.15	1.88	1.36	0.38	0.46	3.67	11.88	0.60	<0.10	0.62	<0.20	<0.10	0.28	<0.10	<0.40	2.41	26.51	97.78
8	53.92	<0.10	1.88	1.11	<0.10	0.43	6.51	14.08	0.56	0.13	0.76	0.37	<0.10	0.46	<0.10	<0.40	1.75	18.42	100.38
9	46.53	<0.10	1.60	1.63	0.28	0.48	5.18	11.14	0.48	<0.10	0.60	<0.20	<0.10	0.62	<0.10	<0.40	1.74	27.31	97.59
opaque red																			
3	57.35	<0.10	2.53	1.96	0.12	0.74	6.83	16.32	0.71	0.16	0.84	0.53	<0.10	1.45	<0.10	3.99	<0.40	5.86	99.39
5	54.19	0.14	2.56	1.35	0.59	0.72	6.81	14.50	1.11	0.18	0.71	0.56	<0.10	2.27	0.33	<0.40	0.74	13.74	100.50
6	53.07	0.15	2.55	1.34	0.49	0.80	6.56	14.47	0.83	0.20	0.67	0.31	<0.10	1.37	<0.10	0.50	0.69	15.77	99.77
7	58.43	0.27	2.35	2.10	0.52	1.92	8.04	16.80	1.17	0.63	0.66	0.35	<0.10	1.26	<0.10	1.12	<0.40	3.87	99.49

Table 6.2: Compositions of glasses determined by SEM-EDXA (see text).

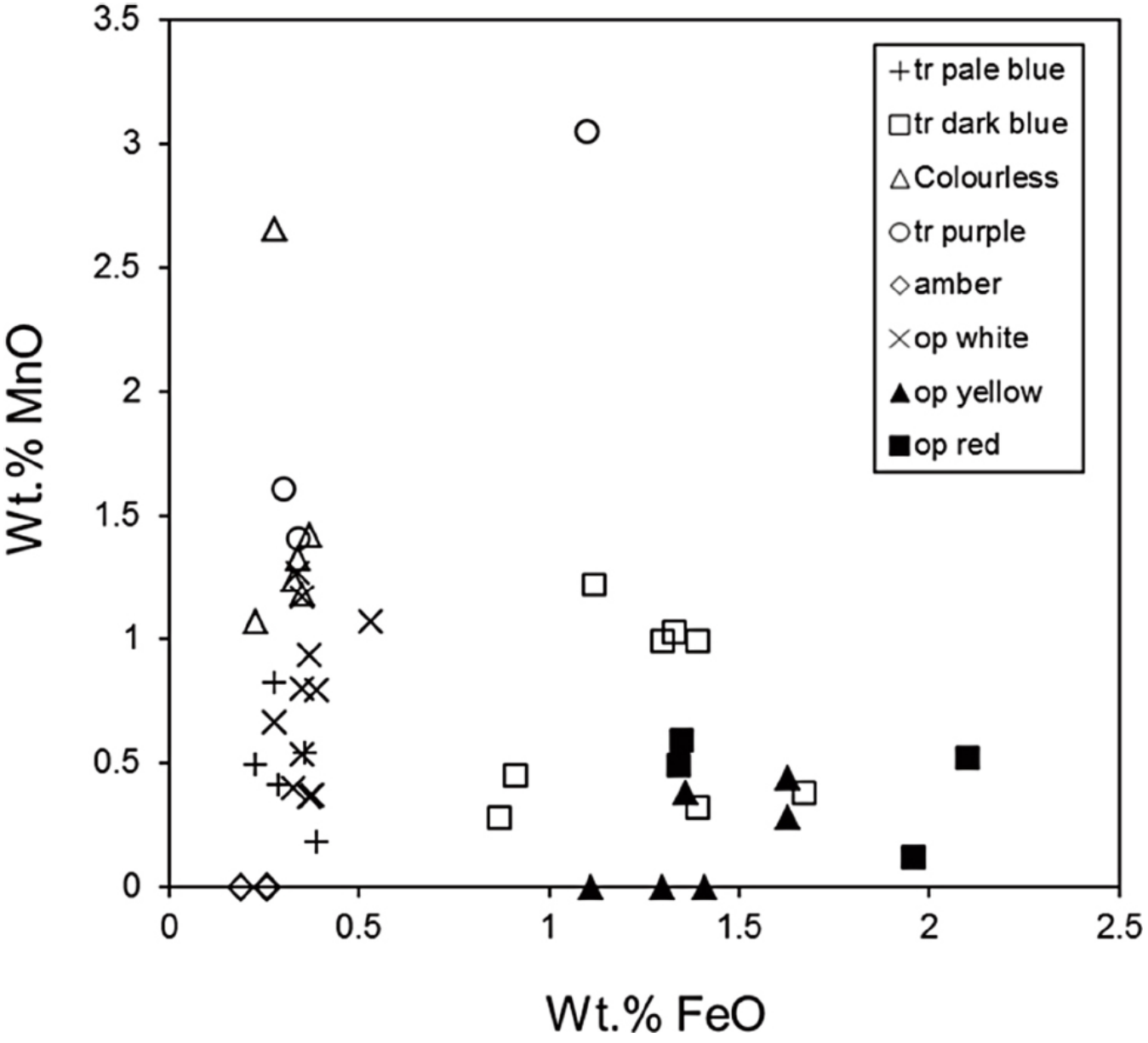

Fig. 6.6: Contents of manganese oxide and iron oxide in the various glass colours analysed.

Amber glasses analysed here are simple soda-lime-silica types with no added colourants or opacifiers (Table 6.2). They have the lowest manganese contents of all the translucent glasses analysed (Fig. 6.6) and it appears that manganese was not intentionally added at any stage. The amber colour is likely to be due to the presence of the ferri-sulphide chromophore, a complex which forms in the glass under strongly reducing conditions. These result in the presence of reduced sulphide, S^- ions, in the coordination polyhedron of Fe^{3+} and this complex generates the amber colour (e.g. Schreurs and Brill 1984; Pollard and Heron *op. cit*.). Low manganese is a typical feature of amber glass (Sayre 1963) because the oxidising conditions it promotes favour the higher oxidation states of sulphur, inhibiting the generation of the amber colour.

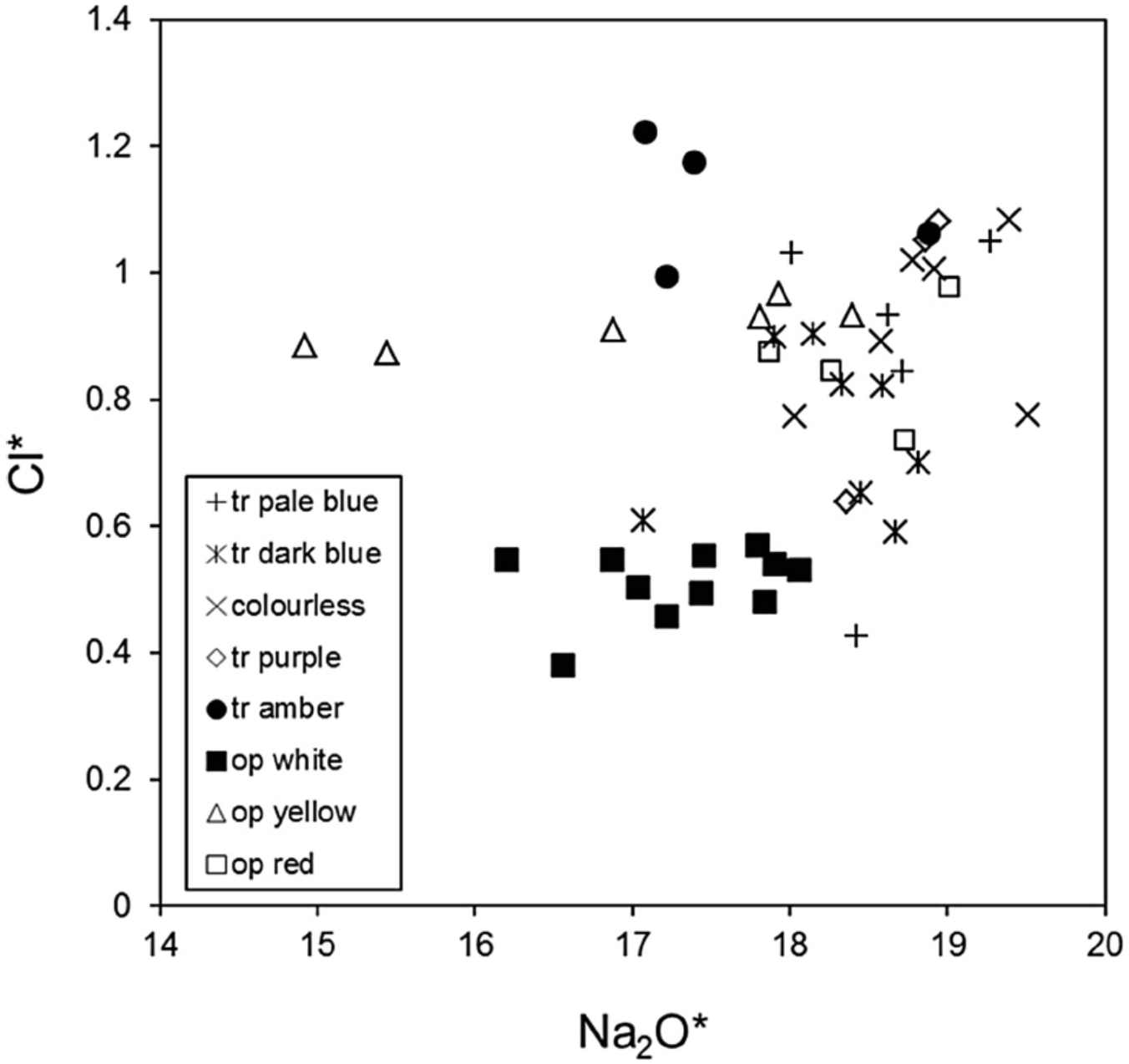

Fig. 6.7: Chlorine versus soda in the various glass colours analysed (indicates reduced weight per cent compositions)*.

The need to maintain strongly reducing conditions would have made it desirable to minimise the length of time that amber glass was reheated in air, after its initial manufacture. The chlorine content of the glass can provide an indication of the extent to which it has been held at high temperature. Chlorine is likely to be present in soda-lime-silica glass as NaCl complexes, as indicated by the presence of very small exsolved particles of NaCl in glasses which have been heat-treated (Barber and Freestone 1990; Barber *et al*. 2009). The amount of chlorine in the glass is therefore likely to be related to the sodium content, but is also dependent upon the duration and temperature of heating, as chlorine is a volatile phase which will be lost from the surface of the molten glass. The amber glasses have the highest chlorine contents of all of the glasses analysed in this project, as shown in Fig. 6.7. This is likely to reflect a shorter period at high temperatures than the other glasses, or fewer episodes of melting, so that less chlorine was volatilised. Amber glass is therefore likely to represent

material used directly from the primary glassmaking furnaces without intermediate phases of melting.

The colourless glasses analysed are all decolourised by manganese, containing over 1% MnO. No other additives were detected and they are compositionally similar in most respects to the amber glasses. The purple glasses are compositionally similar to the colourless glasses and colourless and purple glasses have the highest manganese contents of all the glasses analysed (Fig. 6.6). Manganese is typically present in glass as Mn^{2+}, while the purple colour is likely to be due to the Mn^{3+} ion, which has a very high absorption coefficient so that only very small amounts are needed to generate an intense purple (Schreurs and Brill 1984; Sanderson and Hutchings 1987; Schofield *et al*. 1995). Strongly oxidising conditions are required to oxidise the manganese to Mn^{3+}. Small amounts of antimony oxide, detected in all of the purple samples, but not in the colourless samples (Table 6.2) may have served to oxidise the manganese via the interaction: $2Mn^{2+} + Sb^{5+} = 2Mn^{3+} + Sb^{3+}$, as suggested by Sanderson and Hutchings (1987) for a piece of Anglo-Saxon glass. In the present context, it is observed that the manganese contents of the colourless and the purple glasses are more-or-less the same (Fig. 6.6), suggesting that the antimony content was indeed a critical factor in generating the colour.

Two of the purples contain FeO at about 0.3% and MnO at about 1.5%. The third, from vessel no. 4, contains higher concentrations of these oxides (1.1 and 3.05% respectively) and is a dark purple glass that appears almost black. No cobalt was detected in the dark purple glass above the detection limit of about 0.04% CoO. The very dark nature of this glass is probably mainly due to a greater concentration of oxidised manganese, Mn^{3+}, due to the higher total concentration of MnO, perhaps with a small contribution from the iron.

Opaque white glasses

The opaque white glasses owe their opacity and colour to the presence of abundant crystals of calcium antimonate precipitated in the glass matrix. Antimony concentrations in the range 3–8% seem to have been added to a standard soda-lime-silica glass base. The lime contents of the reduced compositions of the opaque whites are essentially the same as those of the colourless glasses, indicating that the antimony was added as antimony oxide or possibly sulphide rather than as calcium antimonate (Bimson and Freestone 1983; Foster and Jackson 2005).

As is well known, calcium antimonate crystallises or "strikes" in opaque white glass as it is cooled. The precise mechanism responsible for this is rarely discussed, but it may be explained by a consideration of the oxidation states of antimony in the glass melt, which have been measured for example by Claes and Decelle (2001) and by Krol and Rommers (1984). Antimony occurs in two oxidation states, the oxidised form Sb^{5+} and the reduced form Sb^{3+}. The ratio Sb^{3+}/Sb^{5+}decreases as temperatures fall and Krol and Rommers (1984) found that, in a glass they studied, $Sb^{3+}/(Sb^{3+} + Sb^{5+})$ varied from <0.1 to >0.9 between 900 and 1500°C. The form of antimony in the opacifier $Ca_2Sb_2O_7$ is the oxidised variety. Thus, as a glass melt with dissolved antimony is cooled, the antimony oxidises and, given suitable concentrations of antimony and calcium oxides, calcium antimonate precipitates. In order for this reaction to take place, free oxygen must be present in the glass:

$$Sb_2O_3 + O_2 \rightarrow Sb_2O_5$$

In modern glass technology, this oxidation-reduction reaction is exploited in the use of antimony as a fining agent – during melting large amounts of oxygen are released causing the formation of large bubbles which move easily though the melt and remove the smaller bubbles

("seeds"). To produce opaque glass, the oxygen content of the glass should be high, to maximise the formation of the oxidised calcium antimonate phase. The chlorine contents of the glasses investigated here provide evidence that procedures were adopted by the glassworkers to maximise the oxygen content of the glass and the formation of calcium antimonate. Opaque white glasses have lower chlorine contents than all the other colours (Fig. 6.7). This is likely to represent melting for a prolonged period or at higher temperatures. If antimony had been added to the batch as the sulphide mineral, stibnite (Sb_2S_3), or partially oxidised stibnite, a more extreme melting process would have driven off the sulphur and oxidised the antimony, promoting the formation of calcium antimonate. In addition it would also have helped homogenise the antimony in the melt so that the calcium antimonate opacifier was homogeneously dispersed in the glass upon striking.

The estimated accuracy of our sulphur measurements at the lowest concentrations is unfortunately poor, but precision is fair. The whites tend to have higher sulphur contents than most other colours and there is a loose positive correlation between sulphur and antimony (Fig. 6.8). A similar positive correlation between the antimony and sulphur in Roman glass was observed by Fredrickx *et al*. (2004). This suggests that the antimony was originally derived from stibnite but it does not prove that it was added to the glass in mineral form. Foster and Jackson (2005) have demonstrated that it would have been possible to produce an opaque white glass by adding either oxide or sulphide. The sulphur contents of the glasses could be explained by the addition of imperfectly roasted stibnite to the glass (Foster and Jackson, *op. cit*.), coupled with a dependency of sulphur solubility upon antimony content.

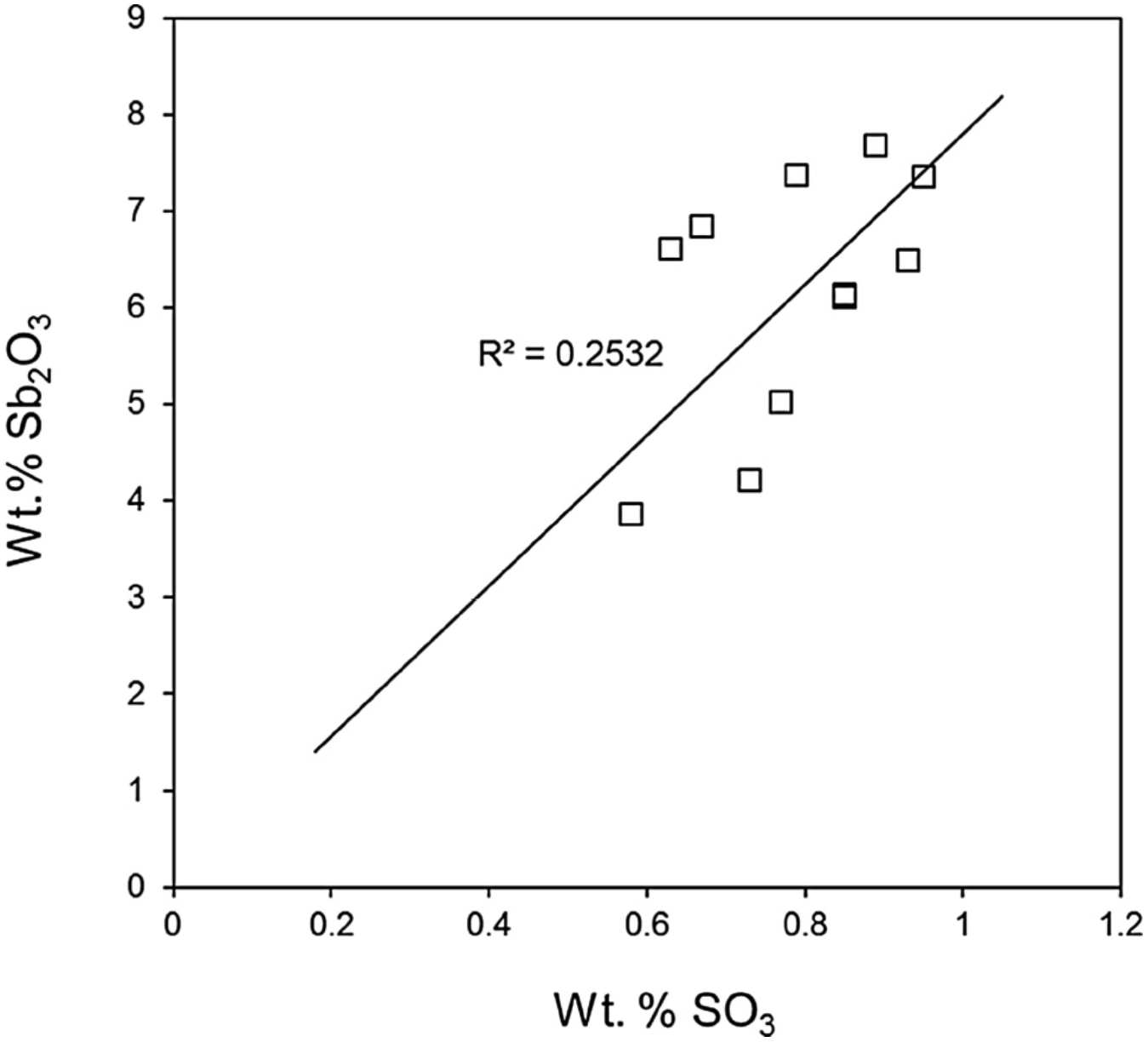

Fig. 6.8: Antimony oxide versus sulphur trioxide in the opaque white glasses.

Two of the white glasses are rich in lead oxide, with around 12% and 15% respectively. This is a characteristic shared by many of the white overlay glasses on cameo vessels from approximately the same period, such as the Portland Vase (Bimson and Freestone 1983; Mommsen *et al*. 1997). These previous investigators speculated that the lead in cameo vessel glass was added to make it softer and hence to improve its cutting properties, or to lower its melting temperature. However, these characteristics would not offer advantages in the production of mosaic vessels. It is therefore possible that an ore rich in lead and antimony was being exploited so that high levels of lead entered some glasses with the antimony. The possibility that there was some technical advantage which has not yet been recognised seems unlikely given the inconsistent presence of lead. One analysed vessel, no. 4, includes both high-lead and low-lead white glass (Table 6.2), so the presence or absence of lead is unlikely to be related to differences between workshops, unless the craftsmen who made the vessels did not make their own colours but received them from specialist colouring workshops.

Blue glasses

Pale blue glasses are coloured with 1–2% CuO. This glass appears bright green when it overlies an opaque yellow, otherwise its appearance is blue or "limpid light blue" (Sayre 1964), which is emphasized when it overlies opaque white. The arrangements of the blue and apparently green glasses in the mosaic patterns are regular, suggesting that the green effect was intentionally produced. Low levels of lead, typically in the range 0.2% to 0.4% PbO, occur in each glass. Tin was measured in four samples at around 0.3% SnO_2, while antimony was detected at similar levels in three. The proportions of copper, tin, and lead are similar to those found in some Roman bronzes, suggesting that copper alloy metal, alloy scale or dross (the oxide-rich scum formed on top of a crucible of molten copper alloy) may have been the source of copper for these glasses (see Brill *et al*. 1988; Sayre 1964).

Eight fragments sampled had a strong blue colour, which is deep enough in some samples to appear opaque. A deep blue colour in glass is typically due to cobalt and quantities of only a few hundred parts per million may impart a strong colouration, while just 5ppm may impart a noticeable tint according to Preston and Turner (1941). Cobalt was measured in four of the glasses at levels of around 0.1%, and was tentatively detected in two more. It is therefore likely to be present in all of them. The iron oxide content of the dark blue glasses is higher than in most other colours (Fig. 6.6), ranging between about 0.9% and 1.7% FeO suggesting that iron oxide was added with the cobalt colourant. Manganese ranges from about 0.3% to 1.2% MnO and concentrations in this range are not exceptional within the overall assemblage and are typical of the base glass (Fig. 6.6), so it is unlikely that large quantities of MnO were added with the cobalt. Copper was present in all samples at levels between 0.05 and 0.5% CuO, and is likely to have entered the glass with the cobalt. Arsenic, frequently associated with cobalt ores in nature, was sought but not detected. One of the cobalt-coloured blues in a short strip mosaic fragment (vessel no. 4) contains about 0.3% ZnO, which may reflect the cobalt source.

In marbled vessel no. 12, very thin streaks of black glass, observed only with the use of a low-powered binocular microscope, occur within the cobalt-coloured blue. Present in the black are sulphur and copper-rich particles, less than 0.001mm diameter, probably a copper sulphide which is responsible for the black appearance. These particles are likely to have precipitated due to the elevated S and Cu in the black region, analysed as around 1% SO_3 and 2% CuO (Table 6.2). Sulphide compounds have been found to be responsible for the black appearance of some other ancient glasses (e.g. Stapleton and Swanson 2002). However, in the present case the inclusion of these very fine black streaks in the host blue glass are likely to be related to the manufacture of the cobalt colourant rather than to the intentional manufacture of a black glass. Cobalt ore commonly occurs in the form of sulphides and is frequently associated with copper mineralisation so it is possible that these streaks represent the use of imperfectly oxidised ore.

The single example of *opaque* blue analysed shows similarities in composition to the translucent cobalt-blues, containing about 1.8% FeO and 0.9% MnO, as well as 0.4% CuO. This glass is opacified by crystals of calcium antimonate, due to the presence of around 7% Sb_2O_3. The cobalt content of this glass, about 0.9% CoO, is much higher that in the translucent cobalt blues, due to the need to counteract the white of the calcium antimonate. This opaque blue appears to have been made by adding the cobalt pigment to an opaque white glass similar to the low-lead opaque whites in the vessels; it is noted that the chlorine content of the opaque blue glass is low, similar to those of the opaque whites.

Opaque yellow glass

Yellow glasses are coloured and opacified by yellow lead antimonate crystals, probably $Pb_2Sb_2O_7$ (Rooksby 1962). Antimony is present at in the range 1.8% to 3.6% Sb_2O_3, while lead occurs between about 18% and 32% PbO (Table 6.2). Thus, the PbO:Sb_2O_3 ratios of the yellows are much higher than those of the two lead-bearing opaque white glasses. In fact, for each yellow, assuming that all of the antimony present is in the $Pb_2Sb_2O_7$ crystals, there is an excess of lead of the order of 15% to 30% PbO over the amount required to combine with all of the antimony. In the early modern period, yellow glass was made by producing a precursor lead-antimony-silicate, known as *anime*, which would be mixed with a soda-lime-silica glass to colour it (Moretti and Hreglich 1984). A similar practice is likely to have occurred in the production of yellow glass in Late Bronze Age Egypt (Shortland 2002) and it was also the practice in the production of the tin-based equivalent opacifier, lead tin yellow, where Heck *et al*. (2003) report early medieval crucibles in which the precursor appears to have been made. For the present glasses, lime is plotted against silica in Fig. 6.9. It is observed that the yellow glasses have elevated silica relative to the other colours suggesting that the yellow colourant was indeed added in the form of a silica-containing precursor. The reduced compositions of the yellow glasses also have relatively low potash and magnesia (Fig. 6.10) supporting the addition of a diluting siliceous material.

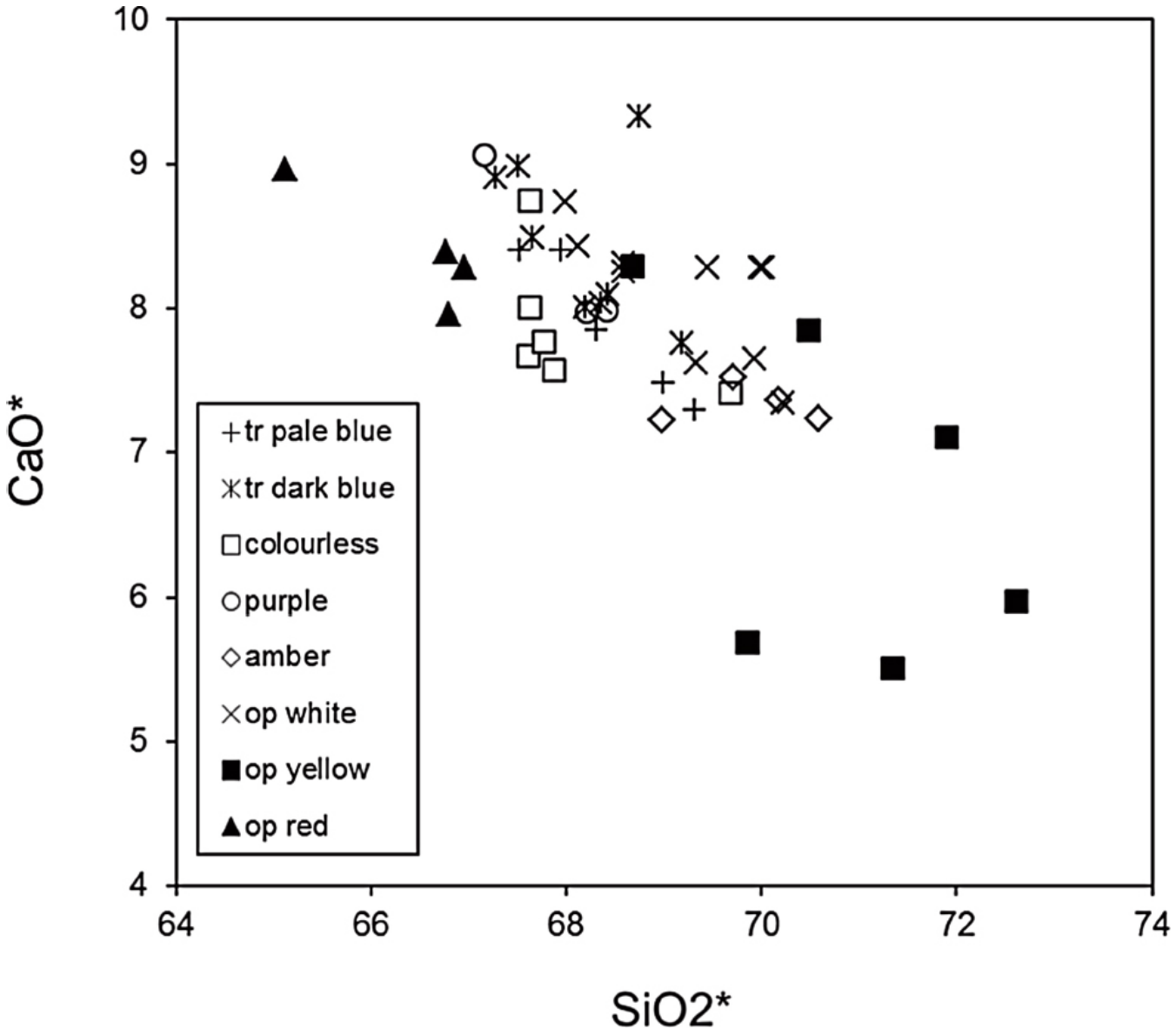

Fig. 6.9: Reduced lime versus silica for the glasses analysed. Note the occurrence of the red and yellow glasses at opposite ends of the distribution.

A lead-antimony-silica pigment was probably used because lead antimonate is a relatively unstable pigment and fades when held at high temperatures, as has been demonstrated experimentally (Shortland 2002). The excess lead is likely to have reduced the melting temperature needed to make the antimonate pigment and a high-lead glassy matrix is likely to have helped stabilise the lead antimonate phase. Lead antimonate does not appear to "strike" (to form during cooling) in the same way as calcium antimonate white. This explains why glasses such as those here and on some cameo vessels may contain high antimony and high lead but still appear opaque white, rather than opaque yellow. It reflects the very different technologies used to produce the two colours. As the colour of lead antimonate is relatively unstable, the glassmakers would have minimised the time that yellow glass was held at high temperature during the colouration process. The chlorine content of opaque yellow is therefore typically high relative to opaque white glass and many other glasses analysed (Fig. 6.7).

The diluting effect of the high lead values make most of the remaining oxides in the yellow glass compositions appear unusually low. Even so, iron oxide is elevated to between about 1% and 1.6% and is higher than in most other colours, except for blues and reds (Fig. 6.6). In all of these colours an iron-rich compound is likely to have been added to the glass as part of the colouration process. In the case of yellow glass we may speculate that iron additions tend to stabilise the lead antimonate and hence make a stronger yellow. Moretti and Hreglich (1984) found that the lead antimonate colours they obtained were stronger in the presence of iron (more orange or brownish yellows).

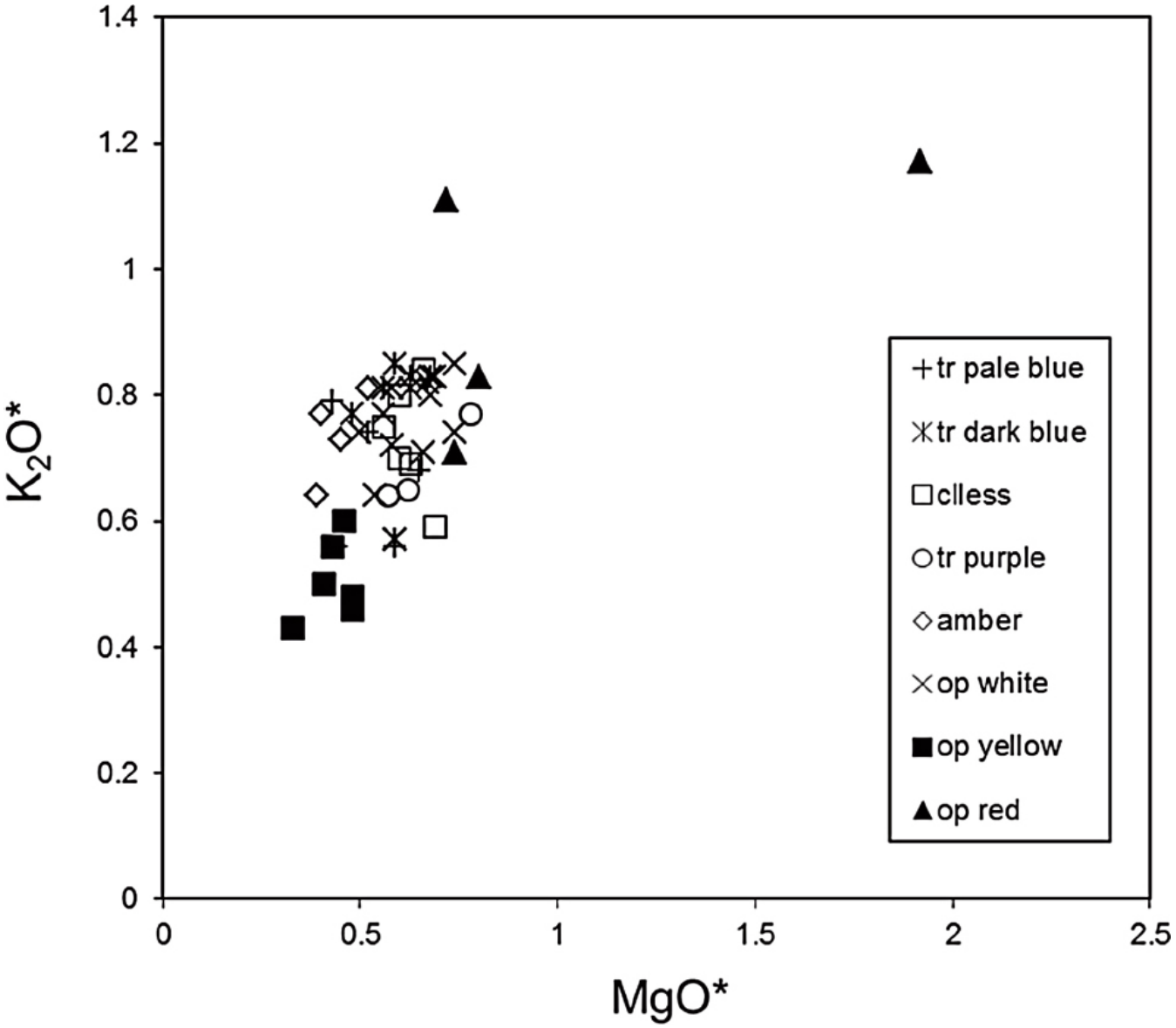

Fig. 6.10: Reduced magnesia and potash in the colours analysed, showing elevated concentrations in the red glasses. Note also the relatively low concentrations in the opaque yellows.

A green opaque glass may be formed by combining a lead antimonate opacifier with a copper blue coloured glass matrix. However, in the mosaic glasses analysed here green was produced by overlaying a translucent copper blue glass on an opaque yellow background. This may be a reflection of the difficulties in controlling the colours of glasses opacified with lead antimonate outlined above or possibly the challenge of manufacturing opaque green.

Dissolution of copper oxide in a pre-existing opaque yellow glass is the most obvious route to green, but the high temperatures needed to dissolve the copper are likely to cause the lead antimonate to dissolve. Addition of lead antimonate pigment to a pre-existing copper blue glass would appear to be more likely to produce a successful glass but would have been a more complex and time consuming process than overlying translucent blue over yellow. Interestingly, in ancient glass cobalt is rarely, if ever, seen in combination with lead antimonate yellow to manufacture a green, presumably as cobalt is too strong a colourant and absorbs too much light to be used successfully in this way.

Opaque red glass

Minute particles of a copper-rich phase, probably metallic copper (Barber *et al*. 2009; Brun *et al*. 1991), of the order of 1μm or less in diameter, colour and opacify the opaque red glasses. 1–2% copper, reported as CuO, is present (Table 6.2) and lead is present between about 4% and 16% PbO. The two reds with the highest lead also have detectable levels of about 0.7% Sb_2O_3. Small amounts of tin and zinc in several of the samples are likely to represent the use of copper alloy scrap as a source of colourant.

Iron oxide is also high in the red glasses (Fig. 6.6), and is likely to have been added as a reducing agent to facilitate the formation of the copper particles (Freestone 1987; Freestone *et al*. 2003). An examination of the potash and magnesia contents indicates that in the opaque reds these are highest of the mosaic glasses investigated (Fig. 6.10). High magnesia opaque reds have been reported in other studies of mosaic glasses (Nenna and Gratuze 2009) and Roman opaque red glasses in general (Henderson 1991a; 1991b). In some cases it has been suggested that they represent plant ash based glass, an alternative source of glass, implying a trade in a material which is inferred to have been more difficult to produce than other colours, and which was more difficult to obtain. However, this is unlikely to be the case for the present glasses. As is indicated by Fig. 6.10, while all four red glasses have relatively high MgO and K_2O, these are only slightly elevated compared to the other (natron-based) glasses analysed. The standard criterion used to distinguish between plant ash and natron based glass is typically around 1.5% each of K_2O and MgO (*e.g*. Lilyquist and Brill 1993). Only one of these red glasses exceeds 1.5% in either of these oxides and this is vessel 7, with 2.1% MgO in its reduced composition, but only slightly elevated K_2O at 1.2% (Fig. 6.10). Relative to (colourless) soda-lime-silica glasses produced using plant ash from any period, Bronze Age to medieval (e.g. Brill 1999; Freestone 2006, fig. 1) these values remain low, and for this reason the suggestion that they represent "plant ash glasses" must be treated with scepticism. However, there is clearly a plant ash signature, as emphasised by the particularly high P_2O_5, another characteristic indicator of plant ash, in vessel no. 7 (0.6%; Table 6.2). The position of these compositions, intermediate between plant ash and natron, suggests that they represent a mixture of either plant ash and natron based glasses, or natron-based glass and plant ash. When reduced lime and silica for all mosaic glasses are plotted, it is observed that silica is lowest while lime is relatively high in the red glasses (Fig. 6.9), which favours the addition of ash, with high lime and low silica, rather than a mixture of two glasses, as soda plant ash and natron glasses typically have broadly similar lime and silica contents. The addition of ash to red glass is explicable in terms of the colouration process. Fuel ash frequently contains finely divided charcoal and its addition to the glass would therefore have served as a reducing agent, favouring the formation of reduced forms of copper and the precipitation of copper metal particles to give the colour.

Discussion

The results presented reflect a highly complex glass colouration technology in the early imperial period, underpinned by a sophisticated empirical knowledge of material behaviour. To produce the range of colours seen in the vessels analysed, the addition of a single colouring agent with minimal preparation was not sufficient. In the case of cobalt blue or antimony-opacified glasses, it was necessary to thoroughly burn and oxidise any sulphide ore used; for lead antimonate yellow a lead antimony silicate precursor compound was produced and iron added to stabilise the colour. Furthermore, the durations of the melting processes were controlled as indicated by the chlorine contents of the white, colourless, yellow and amber glasses. Internal oxidation states of opaque reds were manipulated by adding both iron compounds and carbon (in ash), and in the manganese purples by the addition of small quantities of antimony. These characteristics suggest a well-established and mature colourant technology.

The lime and alumina contents of natron-based glass can be used to evaluate potential sand sources and origins of the base glass (Freestone *et al*. 2000; 2006). Roman vessel glass of the later 1st-4th centuries falls into several compositional groups: (1) common green-blue glass; (2) colourless glass, in which the colour due to iron oxide was removed by additions of antimony; (3) almost colourless glass, decoloured by manganese and similar in other respects to green-blue (Sayre 1963; Jackson 2005). Typical antimony-decoloured glass and green-blue glass may be readily differentiated using major elements such as lime and alumina, which suggests the use of different sands (Fig. 6.11; Freestone 2008). Elemental and isotopic studies suggest that many of these glasses originated in the southeastern Mediterranean (Nenna *et al* 1997; Picon and Vichy 2003; Degryse and Schneider 2008) and the use of eastern Mediterranean sands continued into the middle of the 1st millennium A.D., in the form of the "Levantine I" blue-green glass of late Roman/early Byzantine times (Freestone *et al*., 2000).

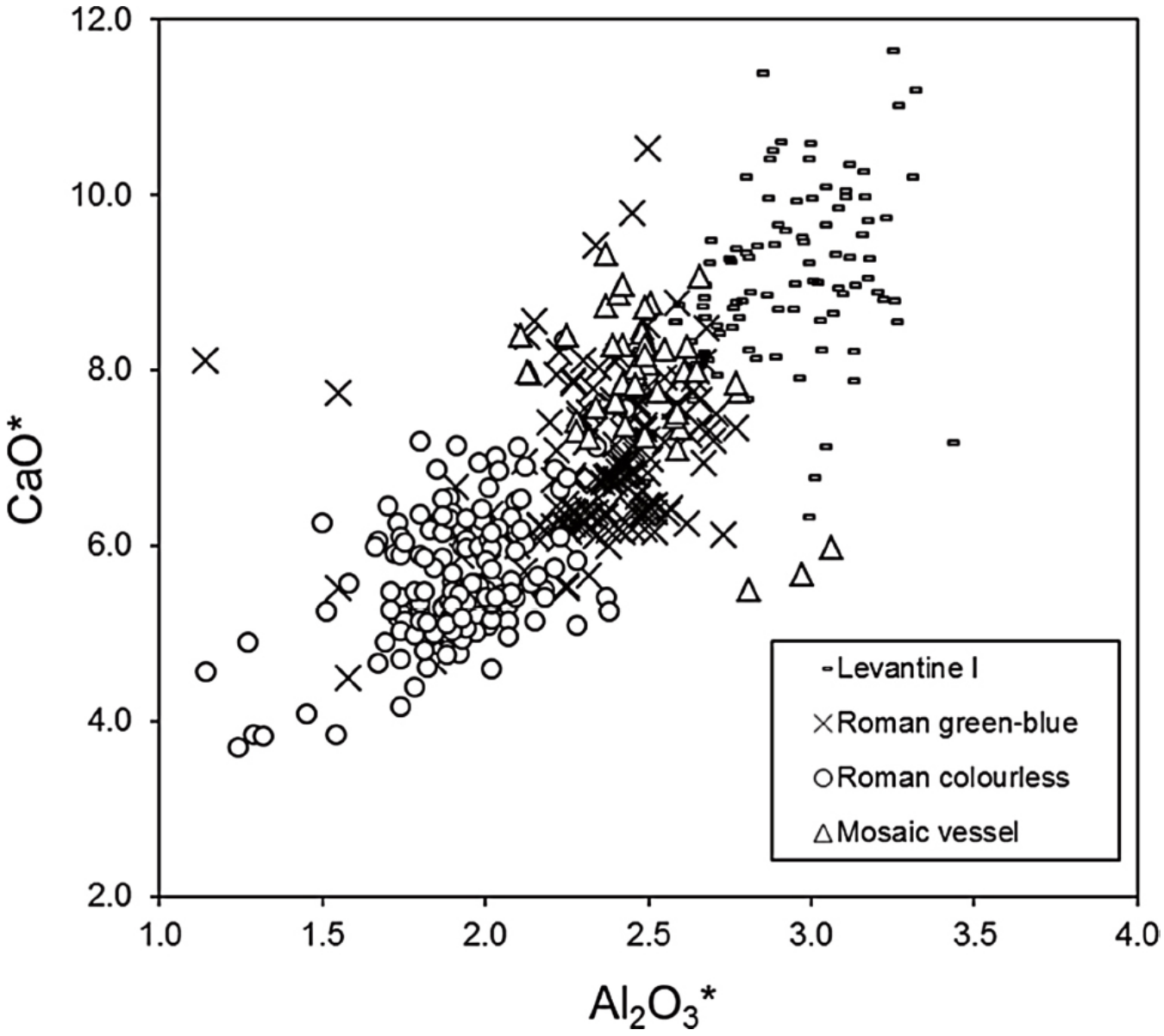

Fig. 6.11: Reduced lime and alumina contents for mosaic glasses analysed here versus Roman weakly coloured (green-blue) and antimony-decolourised colourless glass of 1st-3rd centuries and Levantine I type glass of the early Byzantine period (for sources of data, see Freestone 2008). The small cluster of mosaic glass lying below the main group comprises opaque yellow.

Fig. 6.11 compares the reduced composition of the glass from mosaic vessels analysed in the present study with the Roman colourless, green-blue and Levantine I groups (for sources of data see Freestone 2008). It is observed that the mosaic vessels form a coherent compositional group, apart from three samples which lie below the main cluster. These outliers are opaque yellow glasses and, as discussed above, their deviation is likely to be due to the addition of silicate components with the lead antimonate opacifier. The base glass of the mosaic vessels is very similar to the compositions determined for 1st-3rd century green-blue glass. This is not surprising as Pliny, writing around 70AD, indicates that glass was traditionally made from the sand of the beach near the mouth of the River Belus, which flows into the Bay of Haifa (Freestone 2008). However, it is noted that the mosaic vessels do not fully overlap the Roman green-blue glasses, but are concentrated at higher lime and slightly higher alumina contents (Fig. 6.11). Rather than a change in the glassmaking sand used, this may reflect

changes in production practices in the 1st century AD. The low-lime antimony-decolourised colourless glass does not appear to have become common until after the middle of the 1st century AD, well after the present vessels were produced. The green-blue glasses with lower lime and alumina than the mosaic glasses (Fig. 6.11) may be interpreted as resulting from mixing of this colourless glass with blue-green glass due to glass recycling. The base glass of the mosaic vessels is therefore likely to be representative of Roman glass made from the Belus sand source and use of this sand appears to have continued through to the 4th century.

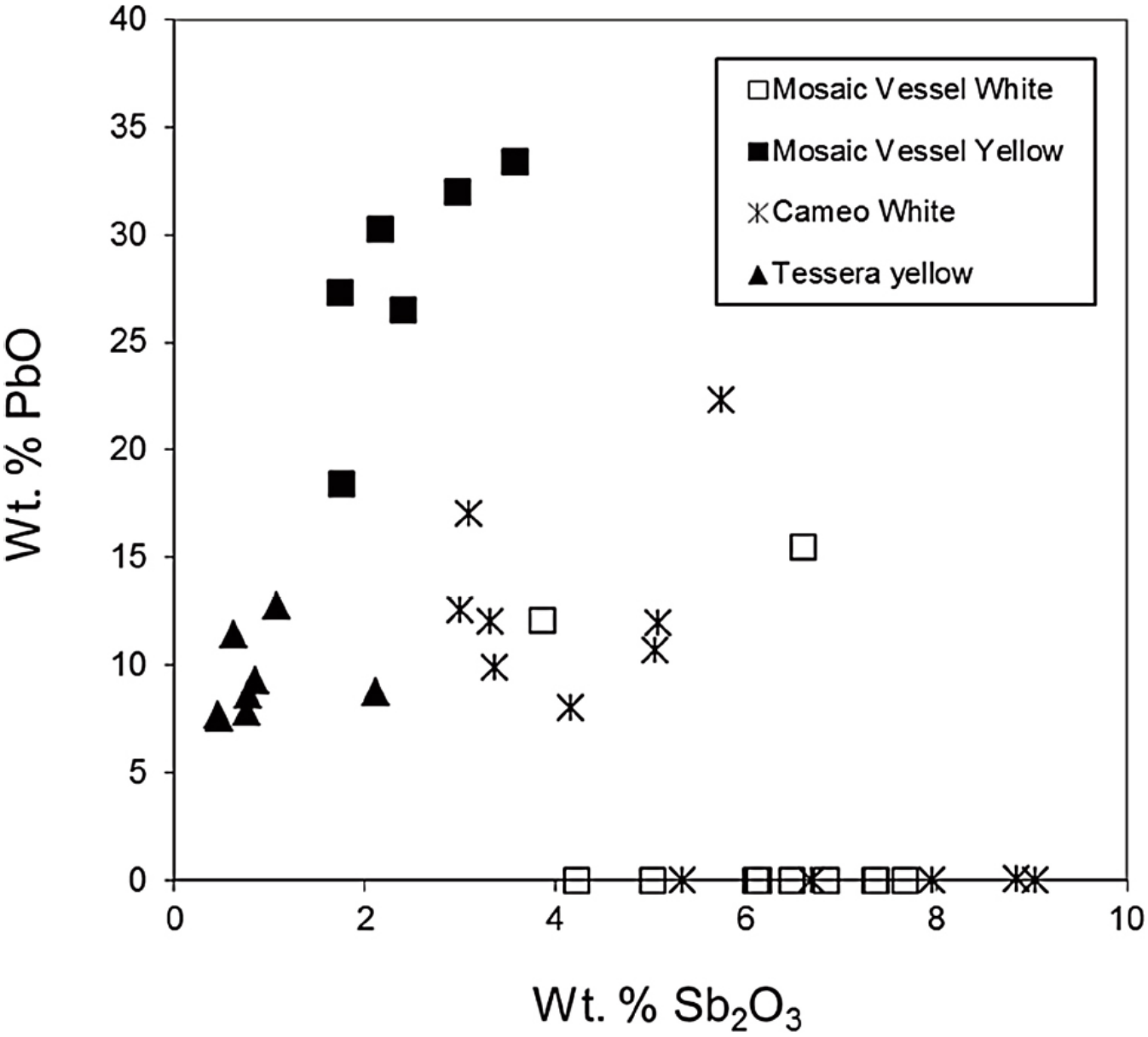

Fig. 6.12: Lead versus antimony oxide in opaque yellow and white glasses analysed, plus white glasses from cameo glass and yellow glass tesserae from wall mosaics of the 1st-3rd centuries.

The fact that the mosaic glasses were made from the standard source of sand for Roman glass, and one which continued in use for some centuries, means that it is not possible to use the sand composition to determine their provenance. Hence it does not help to determine if the colours were made in a single workshop or a number of different workshops. However, this result does suggest that the major expansion of the Roman glass industry which occurred

with the widespread adoption of blowing was possible using the traditional raw material source, and did not depend upon the introduction of new sources of sand. Even so, the coherent and explicable patterns of compositional variation within the mosaic glasses, particularly with respect to components such as chlorine, are consistent with the view that these colours were made in a single workshop or closely related workshops.

Jackson *et al*. (2009) tend to favour a hypothesis whereby *coloured* glasses used to make vessels of the 1st century AD were produced in primary workshops where glass was made from its raw materials and transported to glass workshops around the Roman world. Part of the evidence for this is a type of copper-coloured green glass which has high magnesia, potash and phosphate, interpreted as a plant ash base glass made from different raw materials and hence in a different locality to the natron-based glasses. This green glass was not present in the vessels studied here. A plant ash component is detected in the opaque red glass but it is considered to indicate an addition of ash, rather than manufacture of a primary plant ash glass as such (see above). In contrast to our interpretation, however, we should note that opaque red glasses with elevated magnesia and potash are considered plant ash glasses by Nenna and Gratuze (2009).

There is evidence that some of the amber glasses in our sample shared a primary production campaign as these have a very narrow range of CaO and lower MgO than other colours, particularly if they are compared with reduced, base glass compositions. This distinctive base glass composition is likely to reflect the derivation of the amber for vessels 11, 12 and 13 (British Museum vessels) from a single primary tank of glass. The amber glass in vessel no. 8 (one of the V&A group) has higher soda and is likely to have originated in a different batch. This is not surprising given the different typologies of the vessels. Amber is likely to have been an incidental colour which developed when conditions in the primary furnace were exceptionally reducing. The glass would have been distributed for its colour and care would have been taken not to disrupt the reduced state of the glass by adding oxidants or by melting it with other glass.

There appear to be few significant differences between the compositions of the early imperial opaque glasses analysed here and those in Hellenistic and early imperial mosaic fragments analysed by Gedzeviciute *et al*. (2009). Indeed, there appear to be relatively few differences between the colourant technology used in the mosaic vessels and that seen in later Roman coloured glass, for example in glass tesserae from wall mosaics. The absence of manganese from amber glass, which owes its colour to a very reducing environment, is also a feature of 1st century AD amber vessel glasses surveyed by Lemke (1998) and further considered by Jackson *et al*. (2009). Similarly the manganese and iron contents of the purples match those reported by Jackson *et al*. (2009) and indicate a manganese source which incorporates a subordinate quantity of iron oxide which becomes apparent when higher concentrations of MnO (c. 3%) are present. The dark blue glasses analysed have only iron as an elevated component and generally lack the elevated Ni, As and Zn values associated with cobalt sources used at later dates (Gratuze *et al*. 1995); furthermore the manganese values are typical of the colours as a whole and are not correlated with the cobalt. These dark blues have high iron:cobalt ratios and are typical of Roman and late pre-Roman coloured glass in Europe (Bimson and Freestone 1983; Henderson 1992; Jackson et al. 2009).

There are significant compositional differences between the yellows and whites analysed here and some later glasses of these colours. Comparison of the yellows analysed here with a number of 1st to 3rd-century mosaic tesserae analysed by Stege and Freestone (unpublished) indicates that the later tesserae have lower iron oxide contents. Furthermore, Fig. 6.12 illustrates that the yellows of the mosaic vessels analysed here have higher lead. While these

conclusions are based on a relatively small number of samples, the data of Gedzeviciute *et al*. (2009) support this view for early imperial and Hellenistic mosaic vessels but also suggest that mosaic glass that they attribute to Egypt on stylistic grounds was of the lower-lead type. There is a tentative indication here of two technological traditions in the production of lead antimonate yellow glasses which merits further investigation. The absence of antimony opacified greens in the present study also suggests that the lead antimonate technology may not have been uniformly mastered, perhaps reflecting the challenging nature of this colour.

The variable lead content in opaque white glasses of the early imperial period remains difficult to explain. As is seen in Fig. 6.12, the lead contents of the whites from cameo glasses of the period, such as the Portland Vase, fall into similar compositional ranges to those of the mosaic glasses (Bimson and Freestone 1983; Weiβ and Schüssler 2000), and it is clear from the differences in lead/antimony ratios of the different colours that the leaded whites are not directly related to the production of opaque yellow, for example as failed attempts to make lead antimonate-coloured glass. Rather, they must represent some characteristic of the white production technology. This appears to be restricted to the early Roman period, as antimony-opacified white glasses with high lead do not appear to be common in later assemblages. While use of a mixed ore is possible, the total weight of lead plus antimony oxide is much higher in the leaded glasses, suggesting that lead was not incidentally incorporated with the antimony. Furthermore, there is a compositional gap rather than a gradation between white glasses with lead and those without (Fig. 6.12), which suggests that the addition of lead was a distinctive step in the production process, and was carried out only in specific cases. More work is required to elucidate the role of lead oxide in early Roman glass technology.

Conclusions

This paper presents a substantial addition to the corpus of published analyses of Roman coloured glasses, in particular those from the early imperial period. It suggests that, while the principle colourants and opacifiers of Roman glass were well established by the 1st century AD, there were variations in technology which can be elucidated by careful analysis of carefully defined groups of glass. The concentrations of components typically associated with the base glass such as silica, lime and chlorine can yield important insights into the colouration processes used, while analysis of a significant sample of the same colour from well contextualised samples may allow technological variations with time and place to be discerned. However, the conclusions attainable are not restricted to the details of glass technology. For example, the tight compositional grouping of the amber glasses, suggesting a single batch of primary glass, implies that production of vessels 11–13 was from a single workshop, over a relatively short period. Variations in opaque yellow glass composition suggest that there may have been two traditions of producing this colour, one characterised by higher lead than the other, suggesting that it may be possible to identify different regions of origin, or groups of workshops. Comparison with published data suggests that they may represent Egyptian and Italian production.

As has been shown in a number of other contexts, Roman glass may superficially appear tediously homogeneous in composition, but carefully selected groups of closely related objects, analysed by quantitative methods, may reveal significant compositional groupings that improve our understanding of its technology and production.

Acknowledgements
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7

ROMAN GLASS FROM EAST TO WEST

E. Marianne Stern

Introduction

The Roman Empire is renowned for many inventions and institutions which shaped the cultures of the western world. Among the most enduring is the art of glassblowing. (For a concise general introduction to Roman glass, see Price 1976; 1983; Price and Cottam 1998.) The purpose of this paper is to compare and contrast glass production in the eastern and western parts of the Roman Empire during the 1st to 4th centuries AD. For the East, I focus in particular on the Syro-Palestinian coast, an area that already had a millennium-old tradition of glassmaking and glass-working when it became part of the Roman Empire. For the West, I concentrate on the imperial capital at Rome, with Italy and the adjoining provinces covered by southern France, Switzerland, and Slovenia (with southern Austria).

Sidon's Fame

Our story begins in the East. According to Pliny the Elder (*Historia Naturalis* 36.193), the city of Sidon on the Lebanese coast had been famous once for glass-working: '*…aliud flatu figuratur, aliud torno teritur, aliud argenti modo caelatur, Sidone quondam his officinis nobili…*'. Since Pliny was just in his fifties when he died in AD 79 during the eruption of Mount Vesuvius, the qualification *quondam*, 'once upon a time', suggests he was referring to a time before his birth for Sidon's fame as a glass city, that is before AD 23/24. It also implies that Sidon was no longer famous for glass-working in the seventies. As we shall see, these assumptions do not only agree with the archaeological evidence, they also help to interpret it.

Pliny says Sidon had been famous in the past for three glass-working techniques: shaping by breath, tooling on a turntable and chasing like silver. I will discuss each of these techniques in turn and compare their development in East and West.

flatu figurare

'Shaping by breath' is of course glassblowing. I blew glass for many years, but the almost miraculous fluidity of the material during blowing remains as fascinating as ever. After giving the glass on the blowpipe its first puff of air, the possibilities of transforming the shape of the

bubble are unlimited: a pear-shaped drop becomes a sphere, an egg, a cylinder, a cone, or a cube, depending on how one manipulates the glass.

After coaxing the bubble into the desired shape, one attaches a solid metal rod, known as a pontil or punty, to the bottom (Fig. 7.1), separates the glass from the blowpipe, and holds the piece on the punty to open the mouth with a springy iron tool called jacks in modern workshop parlance (Fig. 7.2; on ancient jacks, see Stern 2002, 162–164). Once the piece is on the punty, one can no longer change the shape of the vessel's bottom, but one can still shape its upper part by stretching, pinching, or flaring the rim out wide.

In order to keep the glass centred while it is being shaped, the glassblower has to keep turning the blowpipe or the punty by rolling the tool back and forth. Today, we do this usually on the arms of a glassblower's bench or chair (Fig. 7.1), but this practical contraption was not invented until the 17th century. In antiquity, the glassblower sat on a small stool directly in front of the furnace (Fig. 7.3). To protect him or herself from the hot tool the artisan probably laid a second pair of jacks on his thighs to support the blowpipe or punty, as does the glassblower in a traditional workshop in Cairo (Fig. 7.2; Stern 2002, 159–160).

Fig. 7.1: The blowpipe with the blown piece still attached rests on the arms of the glassblower's bench. The glassblower grabs with his jacks the tip of a punty (held horizontally by an assistant out of shot to the left) and presses it against the bottom of the piece. Toledo Museum of Art, glass studio (photo author)

During blowing glass seems to defy the laws of Nature. Even if a piece falls off the blowpipe or punty onto the ground, the glass will not shatter as long as it is hot enough. If one reattaches the piece quickly and reheats, one can still restore the shape and finish the piece as planned. I have argued elsewhere, that ancient stories about unbreakable glass and a cup that fell on the floor, got dented, and was hammered back to shape in front of the emperor

(Petronius, *Satyricon* 51) may well have originated with a spectator who witnessed a workshop accident during which a glassblower saved a piece that fell on the floor while he was shaping it (Stern 1999, 442). Even in the unlikely event that our eyewitness understood that the glassblower could perform this amazing act of reparation only because the glass was still hot and soft, subsequent tellers of the story would certainly not have grasped the point. It requires no stretch of imagination to understand how a workshop accident as described above became embellished with physically impossible details such as the glassblower hammering out the dent in a cup of glass that was no longer hot and soft. After all, even Pliny thought that glass could be hammered into relief like silver (see below).

One of the most intriguing aspects of glassblowing is the fact that it took so long before humankind discovered that glass can be blown. Created by a true transmutation of the raw ingredients, glass is the earliest man-made artificial material, dating back to the late 3rd millennium BC. Ancient artisans had been familiar with glass and had produced magnificent vessels and other artefacts for 2000 years before anyone realised that glass can be inflated. Like other major discoveries which have shaped the course of human history, the discovery that hot air will expand heat-softened glass was probably accidental. Similar accidents must have happened previously, but it took an observant artisan to notice what went wrong and why, and – most importantly – to be curious enough to try to duplicate the event.

Our earliest archaeological evidence for inflation comes from the waste of a workshop at Jerusalem dated to the first half of the 1st century BC (Israeli 1991; 2005). The finds include glass tubes which were pinched closed at the lower end and subsequently inflated through the upper end; the edge of the upper end was pulled outward to create a rim. The finds from Jerusalem suggest that glassblowing began with tube blowing. This may be revealing. Glass tubes were used widely in bead-making, because chopping up a prefabricated glass tube was a simple method for making a glass bead with a thread-hole, a so-called drawn bead. Waste from a Hellenistic bead workshop on the island of Rhodes produced large numbers of glass tubes (Weinberg 1969, pl. 84a).

Fig. 7.2: Seated on a stool, the glassblower opens the mouth of a vessel with his jacks. A second pair of jacks on his thighs protects them from the heat of the punty which he rolls back and forth to keep the glass centred. Traditional workshop, Cairo. After Henein 1974, photo opposite p. 16. (Reproduced by permission of the IFAO)

The circumstance that the earliest glass to be inflated was a tube may be an indication that the original accident that sparked the discovery of glassblowing took place during bead-making. If this theory is true, I think it might explain in part why it took so long before inflation was discovered. Ancient glass-workers were often specialised. They produced either vessel glass, or beads and small ornaments, or flat glass. The earliest techniques for producing glass vessels – core-forming, casting, mould-pressing, sagging, and tooling on a turntable – afforded little opportunity for discovering that glass can be inflated, and bead-makers had little use for inflation.

Whereas the initial discovery took place in the East, somewhere along the Syro-Palestinian coast, it was in the West that the art of glassblowing seems to have been perfected. Over a century of experiments, inventions, and improvements separate the first trial inflation of a heat-softened glass tube from fully-fledged Roman glassblowing in the second half of the 1st century AD. Most of the tools and techniques, now taken for granted as integral to the craft, were invented during this period: the glassblower's furnace with a closed heat chamber, the iron blowpipe, the introduction of molten glass for gathering, and the pontil technique for fire-finishing the vessel's rim. (For an indepth discussion of each of these innovations and their significance for the development of glassblowing, see Stern 1999, 442–454.)

Fig. 7.3: Seated on a stool in front of his furnace an ancient glassblower blows a tall-necked bottle. Roman oil lamp from Skolarice, Slovenia, c. AD 70. Koper, Regional Museum. After Lazar 2004, 27, fig. 15. (Bypermission)

Most if not all of these innovations took place in the West. Furnace builders and blacksmiths in the West could benefit from the high quality iron available such as that from Magdalensberg, in southern Austria (Dolenz 1998), and from local expertise and know-how about metalworking. It is probably not fortuitous that several Roman oil lamps depicting the new glassblower's furnace were found in north-east Italy and Istria. An oil lamp excavated in Slovenia is by far the best preserved (see Fig. 7.3). The disk shows a glassblower at work in front of a small, two-storey furnace. The lower compartment served for stoking, the upper compartment is the closed heat chamber for heating and reheating the glass on the blowpipe. The opening (working port) seems to be closed by a large pot sherd. The master glassblower sits on a small stool and blows a tallnecked bottle; the assistant on the other side may be working a pointed bellows of the kind common in metalworking furnaces. (For a detailed description of the scene, see Lazar 2005.) Numerous remains of small Roman glassblowing furnaces have been excavated in the western part of the Roman Empire (e.g. Amrein 2001; Arveiller-Dulong and Nenna 2006, 22–23).

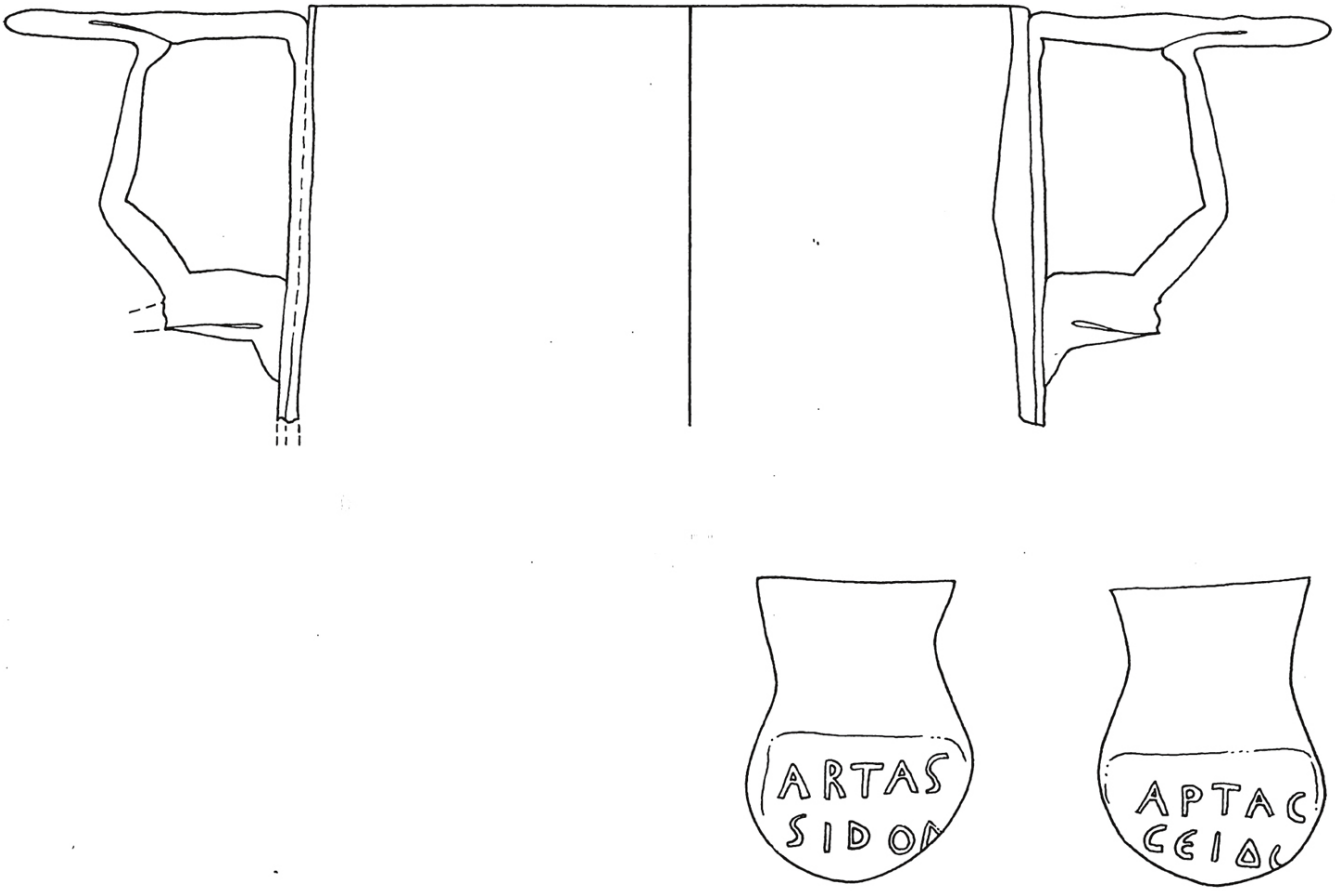

Fig. 7.4: Two-handled cup (skyphos) with handles stamped by Artas the Sidonian in Greek and in Latin. From Rome. First half of 1st century AD. Rome, Gorga Collection, reconstruction drawing. After Del Vecchio 2004, 74, fig. 57. (By permission)

There seems to be general agreement among scholars that commercial glassblowing began under Augustus. After more than a century of civil strife, his rule brought peace and prosperity to Italy. The city of Rome acted as a magnet, attracting artisans from all corners of the

Empire, among them some of the best glassblowers from the eastern Mediterranean coast. We know many of their names because they impressed them with pincers on the handles of two-handled cups (skyphoi), some proudly adding that they hailed from Sidon. I have argued elsewhere that these were the men who may be credited with bringing the art of glassblowing from the East to the West (Stern 1995, 68–69). One of these glassblowers was Artas, who appears to have set up business in the capital itself. He made sure everyone could read his signature by stamping 'Artas Sidon' in Latin on one handle and in Greek on the other (Fig. 7.4). This was easy because the pincer carried a different inscription in negative on either jaw; all the glassblower had to do was turn the pincer 180 degrees when he or she pinched the second handle (Del Vecchio 2004, 31–35, figs 52–70).

The new glassblower's furnace and the new iron tools soon enabled glassblowers in the West to produce a wide range of elegant, large blown vessels. Some of the most magnificent pieces known to me come from the vicinity of Brescia. The jug illustrated in Fig. 7.5 is particularly well-designed. The dragged threads are admirably suited to the aesthetics of the shape. A masterpiece by any standard, ancient or modern, the jug is 25cm high and weighs 495g. I have argued elsewhere, that glassblowing may have begun with inexpensive ceramic blowpipes made by the glassblowers themselves (Stern and Schlick-Nolte 1994, 81–85; Stern 1995, 39–43), but a piece of this size and weight could not have been blown without a sturdy iron blowpipe and a furnace with a closed heat-chamber. I do not know anything comparable from an early 1st-century eastern Mediterranean find-spot.

Fig. 7.5: Translucent yellowish brown glass jug, decorated with melted-in opaque white threads. From Dello (Bs), tomb 3. First half of 1st century AD. Probably made in north Italy. Milan, Soprintendenza archeologica, inv. St. 122676. H 25cm. (Photo R. Lierke, by permission)

In the beginning, glassblowers in East and West alike copied shapes and decoration already existing in other materials such as pottery and metal (on interaction between glass-workers and ceramicists, see Stern 1998). In this field, too, glassblowers in the West developed a much larger variety of decorative techniques than their colleagues in the East. For example, one of the decorative techniques invented in the West imitated contemporary pottery decorated with sand (Fig. 7.6). Instead of sand, the glassblowers used crushed glass.

Vessels decorated with crushed glass in relief were popular for just a short period in the first half of the 1st century AD (Fig. 7.7). Glassblowers abandoned the technique when they discovered they could do something potters could not. By rolling the bubble on the blowpipe through crushed glass before fully inflating the vessel, the glassblower could create coloured flecks evoking a precious stone, just like mosaic glass. The crushed glass softened and, during blowing, expanded with the vessel's walls and flattened out, flush with the wall: individual grains became circular flecks on the bulbous lower body and elongated vertically in the upper body and neck (Fig. 7.8). A variant technique made use of failed glass vessels. Broken into small pieces, colourful shards were applied to the walls of the new piece (Fig. 7.9). Modern glass artists call this 'marquetry.' The American glass artist Joel Philip Myers blows magnificent sculptural pieces with three-dimensional designs made this way.

The shapes of early tableware blown in the West (see Figs 7.7, 7.8) are also much more varied than those produced in the East. In addition to high quality glass tableware, excavations in the West have produced a plethora of other free blown glass vessels that served a wide variety of functions. All this excavated material shows that in the 1st century AD the glass vessels blown in the West were not only far more sophisticated than those blown in the East, but also that blown glass played a larger role in many more areas of daily life.

torno terere

The second type of glass for which Pliny says Sidon had once been famous was that tooled on a turntable, *torno teritur* in Latin. Before Rosemarie Lierke suggested that in antiquity hot glass was actually made into vessels on a wheel (Lierke 1993a, 1993b), modern interpreters and translators misunderstood Pliny. They translated the phrase as "ground on a lathe" (Grose 1977, 16 citing Pliny *HN* 36.193) and assumed that it referred to cold work (Mutz 1972, 172–176). This is no surprise, since the turntable is no longer part of glass studio equipment. Interestingly, Lierke's interpretation of Pliny's text finds support in philological research. Just around the time she began looking for evidence for the use of the turntable in ancient vessel glass production, the German linguists who prepared the newest scientific edition of Pliny's book 36 concluded independently that Pliny's phrase should be translated as 'tooled on a turntable' (König and Hopp 1992, 127; *durch Bearbeitung auf der Drehscheibe*).

Fig. 7.6: Pottery bowl decorated with sand (detail). Excavated at Augst, Switzerland, but probably made in Lyon, France. 1st century, probably before AD 70/80. Römermuseum Augst, no. 1969.15042. (Photo U. Schild, by permission)

Fig. 7.7: Glass tableware decorated with opaque white crushed glass. From Adria. 1st century AD. Museo Archeologico Nazionale di Adria. After Bonomi 1996, col.pl. VII. Sizes of vessels from left to right: L 19.5cm; H 7.6–8.6cm; H 5.8cm. (By permission)

Fig. 7.8: Translucent purple glass amphora, decorated with opaque white and orange flecks. From Carpenedolo (Bs), tomb 1. First half of 1st century AD. Probably made in north Italy. Milan, Soprintendenza archeologica, inv. St. 78987. H 27cm. (Photo L. Monopoli, by permission)

Glass historians are familiar with Rosemarie Lierke's work on 'glass pottery' (Lierke 1999). She has suggested that a number of glass-forming techniques could have relied on the use of a turntable. Lierke's suggestions are controversial, but as a practising glassblower who has been involved actively in testing several of her reconstructions, I have come to the conclusion that in many cases her proposals provide the best currently available explanation for irregularities and tool marks observed on ancient glass vessels. The technique or techniques which Pliny had in mind when he wrote *aliud torno teritur* were most probably those which made use of a re-usable convex mould that resembled an upside down bowl placed on a slowly turning wheel.

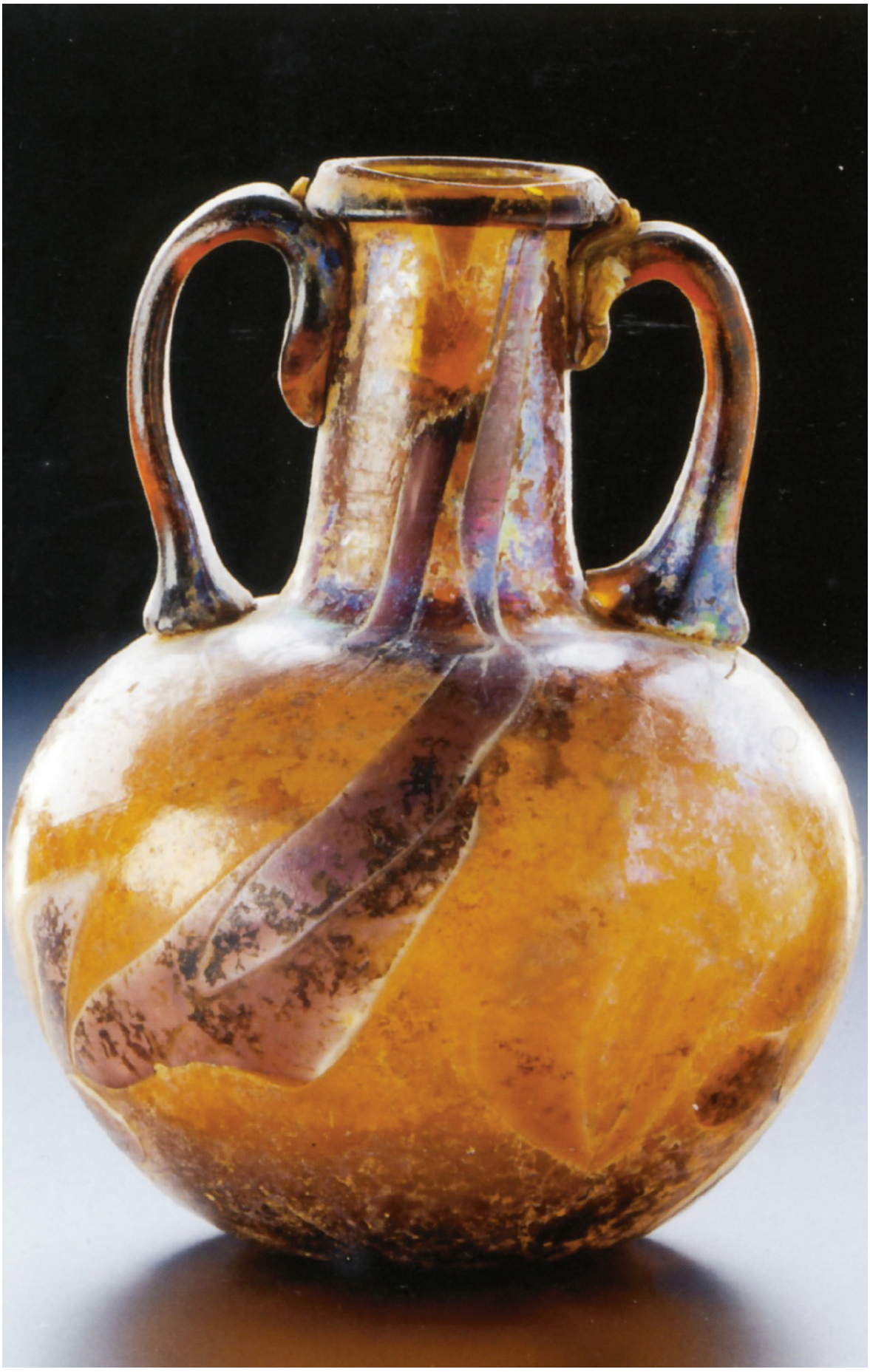

Fig. 7.9: Translucent yellowish brown glass aryballos, decorated with applied bicoloured sherds. Mid 1st century AD. Stuttgart, Landesmuseum Württemberg, formerly Ernesto Wolf Collection. After Stern 2001, no. 11. H 11.2cm. (Photo P. Frankenstein and H. Zwietasch)

The most characteristic product of tooling on a turntable is the ribbed bowl (Fig. 7.10). Note the tool marks in the rim area. Irregularities in length and placement of the ribs are evidence that each rib was tooled individually (Lierke 1999, 51–55; Lierke 2009, 52–55; cf. Weinberg 1970, 26 who already spoke of 'tooled ribs'). Lierke's reconstruction of the technique shows the basics of the operation (Fig. 7.11). A cake or disk of hot glass is placed on a mould. By turning the mould slowly, the glass-worker can remain seated while he or she presses the edge of the glass against the mould to stem the flow of the glass. This action creates the rim of the bowl. (Several classes of ancient vessels made on a potter's turntable show slanting or horizontal tool marks in the rim area caused by this operation.) Then the glass-worker strikes the glass at regular intervals. The glass displaced by striking forms the ribs. Individual workshops probably developed their own tools and routines, just as glassblowers develop specific routines.

Fig. 7.10: Translucent yellowish brown glass ribbed bowl. Note the tool marks in the rim area. Eastern Mediterranean. Second quarter to end of 1st century BC. Stuttgart, Landesmuseum Württemberg, formerly Ernesto Wolf Collection. After Stern and Schlick-Nolte 1994, no. 84. H 6.4–6.2cm. (Photo P. Frankenstein and H. Zwietasch)

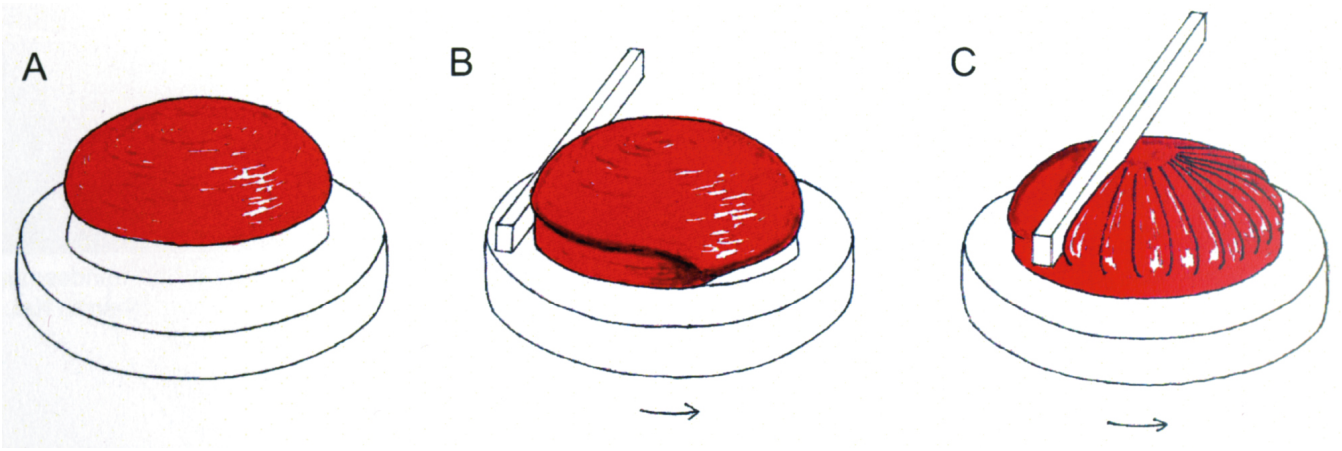

Fig. 7.11: R. Lierke s reconstruction of the production technique of ribbed bowls: A a thick glass cake is sagged over a mould, B the rim is pressed flat against the mould while the wheel turns, C the interstices are indented while the wheel turns. After Lierke 2009, 54. (By permission)

Two expert glassmakers in Britain, Mark Taylor and David Hill, have independently developed a different method for making ribbed bowls. I am very grateful to them for inviting me to their workshop in 2006 and giving me an opportunity to see them at work. Instead of shaping the bowl and creating the ribs simultaneously, they perform the operations one after the other: first they make a disk of hot glass, then they pinch the ribs one by one, in groups of four to seven at a time, smooth the rim, and finally they sag the ribbed disk over a convex mould. The ribs are pinched in groups of four to seven at a time because the disk needs to be reheated in between to keep the glass soft enough for pinching. The result is exquisite. It takes about 14 to 15 minutes to complete one bowl. Pinching the ribs and smoothing the rim is particularly time-consuming because the disk needs to be reheated up to seven or eight times in order to keep the glass soft enough for shaping it (reports of Taylor and Hill's work may be found at http://www.romanglassmakers.co.uk/poster03.htm (accessed 1.1.2008)).

Practical experiments in the Toledo Museum of Art glass studio showed that a ribbed bowl can be made on a turntable in about two minutes time without reheating (Stern and Schlick-Nolte 1994, 72–79, figs 138–142). Since ribbed bowls were mass-produced in antiquity, time would have been a significant factor in production. Tooling of hot glass on a turntable allowed the artisan to create a sturdy open vessel even faster than was possible by blowing. I think this was one of the reasons why the production of ribbed bowls continued long after glassblowing became common.

In my opinion, Lierke's hypothesis regarding the production of ribbed bowls provides more than just the most convincing explanation currently available for the idiosyncrasies of ancient ribbed bowls. It fits in with the history of ancient technology. Lierke suggests that spiral reticella bowls were made on a slowly turning wheel (Lierke 1993a, 34–37; 1999, 39–41; 2009, 40; cf. Stern and Schlick-Nolte 1994, 71–72). Her reconstruction of the manufacturing technique presupposes the same set-up – with a re-usable convex mould placed on a turntable – as her reconstruction of the production technique of ribbed bowls. Spiral reticella bowls originated in the eastern Mediterranean in the Hellenistic period. They predate the earliest ribbed bowls. When glass-workers in the area began experimenting with the production of ribbed bowls, they were already familiar with the advantages of placing a convex mould on a turntable to shape and manipulate hot glass.

Other early vessels made by sagging over a static or slowly turning mould include conical and hemispherical Hellenistic grooved bowls with their characteristic convex bases (Grose

1989, 193–194) and so-called linear-cut bowls which have flat or slightly concave bottoms; the shapes of the latter resemble those of ribbed bowls except that they are decorated with horizontal grooves instead of vertical ribs (Grose 1989, 247). All three types of vessels (ribbed, grooved, and linear-cut) were exported from the eastern to the western Mediterranean in the second half of the 1st century BC (Foy 2005). Stacks of delicate linear-cut bowls and ribbed bowls from a shipwreck off the French Mediterranean coast attest to sea-borne trade (Foy and Nenna 2001, 105, ill.). One early ribbed bowl with irregular short ribs reached Britain (Price 1996).

The archaeological evidence suggests the technology of 'glass pottery' became known in Rome before the end of the 1st century BC, presumably shortly before the art of glassblowing was introduced. The ribbed bowls made in the West differ from those made in the East. The western bowls look standardised; the ribs seem almost regular and the exterior of the rim is frequently ground and polished so the ribs all end at the same height. Nevertheless, careful scrutiny shows that these western bowls still exhibit the same irregularities as those made in the East, be it to a lesser degree. I think we should credit glass-workers in the West with the standardisation of the ribs. Obviously, they improved the production technique and/or developed new or better tools.

If Pliny's remarks about tooling on a turntable have been associated correctly with ribbed bowls (Lierke 1993b), this would agree with the archaeological evidence. The ribbed bowl originated in the eastern Mediterranean (Grose 1989, 195). Danièle Foy (2005) published a series excavated at Beirut which are thought to have been made locally. Ribbed bowls were particularly common in the Palestinian area in the second half of the 1st century BC (Gorin-Rosen 2006). The exact date of their first appearance is still a matter of discussion. One of the earliest examples may be a bowl from a sealed context at Jerusalem dated to the end of the 2nd to the very beginning of the 1st century BC (Gorin-Rosen 2003, 365, 378, discussion of G 15).

In north-west Europe ribbed bowls are so common that they are regarded as a *leitform* of the Julio-Claudian period. Production in the West appears to have continued considerably longer than in the eastern Mediterranean. They were still popular in Italy when Mount Vesuvius erupted in AD 79: eight brand-new bluish green shallow ribbed bowls were for sale in a shop at Herculaneum destroyed by the eruption (De Franciscis 1963; Scatozza Höricht 1986, 27–30, nos. 3–10).

argenti modo caelare

The third technique for which Pliny says Sidon had been famous in the past was 'chasing like silver' *argenti modo caelare*. This is an error on Pliny's part. It is not possible to create embossed relief decoration in glass by hammering or chasing it like silver (on the techniques and tools for decorating silver with relief, see Strong 1966, 9–10; Sherlock 1976, 17–20). Even if one translates *caelare* literally as engraving with a *caelum* (A. Locher, in Lierke 1999, 12), the equivalent of which in glass decoration would be wheel-cutting with water and an abrasive, Pliny cannot have meant engraving, because the earliest engraved glass vessels date from after his death. Nor was Pliny thinking of facet-cut glass which became fashionable towards the end of the 1st century AD. Facet-cutting had no precursor in silver, bronze or gold. I know of no late Hellenistic or early imperial figural or facet-cut glass vessels which can be associated with the Syro-Palestinian coast (Stern 2000, 166–167).

There exists however a distinct glass-forming technique that imitates to perfection silverware decorated with relief. It is mould-blowing. Clasina Isings (1957, 45) drew attention

to the fact that the delicate relief of mould-blown vessels 'looks embossed as well on the outside as on the inside.' Apparently, Pliny did not know how such vessels were made and reasoned that they were produced by the same technique as their metal counterparts. An ancient glassblower queried on the subject may well have left him in the dark or even misled him on purpose. The same misconception appears in Martial (*Epigrams* 14.94): *audacis plebeia toreumata vitri* 'plebeian chased cups of dreadnought glass.' (Translationby Ker 1968, 473; cf. Stern 2012 "plebeian cups chased of fearless glass".)

Mould-blowing makes use of concave moulds. The earliest moulds, used predominantly in the East, were multipiece moulds, usually with three or more parts to avoid undercuts that would impede extraction from the mould (see Stern 1995, 28 for a chart of mould construction types based on the mould seams of mould-blown vessels in the Toledo Museum of Art). The development went from complex moulds to simpler two-part moulds, the latter being favoured in Italy and the West after the mid 1st century AD. Mark Taylor and David Hill (see above) have done excellent work in recreating multi-part terracotta moulds and demonstrating how to use them successfully (Stern 2010, 32–33, figs 7–9).

Jennifer Price (1991) published an informative essay on decorated mould-blown tablewares in the early Roman Empire. Based on datable finds from the western provinces and Britain, which appear first in Tiberian to early Claudian contexts, she came to the conclusion that mould-blowing was invented 'in the first part of the second quarter of the 1st century AD' (Price 1991, 64) and she argued that long accepted arguments for an eastern Mediterranean origin were no longer persuasive. In her opinion, 'the possibility that mould-blowing commenced elsewhere in the Roman world [was] worth consideration' and she suggested an early production centre was located perhaps in Italy (Price 1991, 71). In my opinion, new archaeological discoveries and close scrutiny of the philological evidence suggest otherwise.

Although Pliny obviously did not understand how they were made, his remark about Sidon's one-time fame for glass vessels that looked embossed like silverware, points to Sidon as an important production centre and, perhaps, the origin of the technique. One of the earliest artisans producing decorated mould-blown vessels was Ennion. The location of his workshop has not been established, but there are reasons to believe it was somewhere along the Syro-Palestinian coast. His name and inscribed mottoes point to a Semitic background (Lehrer 1979, 14; on Ennion's close connection with the East see also Barag 1996; Stern 1995, 69–73). His speciality was mould-blown tableware: jugs and cups, often decorated with vertical ribbing and/or floral designs in low relief that were inspired by silverware. More than thirty glass vessels bearing his signature and excavated all over the ancient world from Israel to Spain and along the north coast of the Black Sea, testify to Ennion's success not only as a glassblower and/or mould-maker, but also as a business man. A three-quarter view from above into a cup excavated in north Italy (Fig. 7.12) shows how the ribbing on the exterior corresponds to fluting on the interior. His mould-blown signature in Greek, *Ennion epoiêsen*, 'Ennion made it' is enclosed in a decorative *tabula ansata*, a frame with handles.

I have argued that commercial mould-blowing probably began in the late Augustan or early Tiberian era (Stern 1995, 70–71). If the initial assumption of this paper is correct, that a man in his early to mid fifties would associate *quondam* 'once upon a time' with the time before his birth, Pliny's phrasing indicates that Sidon was famous for decorated mould-blown glass vessels before he was born (*i.e.* before 23/24 AD). A date in the first quarter of the 1st century AD agrees also with the Augustan date (pre-14 AD) assigned to a deposit at Magdalensberg, Austria, that produced the earliest mould-blown fragment currently known (Fig. 7.13; Czurda-Ruth 1998, no. 782). The fragment preserves the remains of a *tabula ansata*, known only from vessels made by Ennion and his contemporary Aristeas the Cypriot.

Other early mould-blown vessels typical of the eastern Mediterranean are small hexagonal bottles decorated with high relief, and small flasks imitating the shape of a wrinkled, dried date (Stern 1995, 74–96, and nos. 15–114).

Mould-blowing may have been introduced into Rome in the early 1st century AD, but, unlike free blowing, mould-blowing did not thrive in the West before the mid 1st century AD (see Price 1991, 67–69). The story about an ancient glassblower who presented the emperor with an unbreakable glass cup is relevant in this connection because it may provide an explanation for the fact that mould-blowing began considerably later in Italy than in the East. The fable of the artisan hammering out a dent in the vessel's wall recalls Pliny's assumption that relief-decorated glass (*i.e.* mould-blown glass) was chased like silver with hammers and punches. Pliny records that the glassblower had no luck with his gift. After learning that no one else knew the secret, the emperor had the artisan put to death and his workshop destroyed because unbreakable glass 'might cause a devaluation of metals such as copper, silver, and gold' (Pliny, *HN* 36.196). If Pliny associates the invention of malleable glass correctly with the emperor Tiberius, mould-blowing may have experienced an early setback in Italy under Tiberius' rule. It was not until after his death in AD 37 that workshops in Italy began producing mould-blown tableware and other vessels. In the eastern Mediterranean, where glassblowers could explore the new technique far from the dangers of the capital, commercial mould-blowing began in the early 1st century AD.

Fig. 7.12: Translucent deep blue mould-blown cup (skyphos), signed by Ennion. Found at Caresana (Vercelli) with a coin of Claudius of AD 46. Torino, Museo delle Antichità, no. 3302. H 6.0cm. (Photo museum, by permission)

The earliest typically western style mould-blown vessels (unknown or extremely rare in the eastern Mediterranean) are so-called sports cups. Sports cups occur frequently in Claudio-Neronian and early Flavian contexts (Price 1991, 67–71), but their production may have begun slightly earlier (cf. Taborelli 2003, 238–239, with n. 51). The decorative imagery suggests a

connection with circus games in Rome, but unfortunately very few sports cups from Italy have been published. Almost all examples come from the northwestern provinces: Britain, Switzerland, and France (Sennequier *et al*. 1998). Other shapes such as knobbed beakers were almost certainly blown in both the East and the West (Stern 1995, 103–108). The mould seams on extant glass vessels indicate that those found in the West were blown frequently in two-part moulds rather than in multipart moulds, as was common in the eastern Mediterranean. It looks as though glassblowers in Italy simplified the mould construction.

Mould-blown tableware decorated with relief was destined to go out of fashion in Italy just around the time that Mount Vesuvius erupted. I think the abandonment of the technique was spurred in part by the increased use of moulds for mass-producing utility wares (see below). With the realisation that fine glass vessels decorated with relief were not individual works of art but could be mass-produced, their value dropped accordingly.

Perhaps it is not fortuitous that in Asia Minor and elsewhere in the East, where mould-blowing did not become a means of mass production, elegant mould-blown beakers featuring mythological imagery remained in use well into the 2nd century AD (Wight 1994). Surprisingly, recent excavations have brought to light an increasing number of fragments of so-called mythological beakers in the area around Narbonne, the Roman capital of Gallia (Fontaine and Foy, this volume). Although we do not yet know where these beakers were made, their presence in southern France is an indication that they remained popular also in this area.

However this may be, it seems that very soon glassblowers in the West realised that mould-blowing would speed up and facilitate the production of utility wares such as storage bottles. I would like to credit glassblowers in north Italy with the invention of the smooth-walled mould. In Italy and the north-western provinces of the Roman Empire the mould-blown square bottle became a *leitform* of the late 1st and 2nd centuries AD (Cool and Price 1995, 179–198). Many square bottles carry an inscription or base-mark on the underside. They were blown in moulds with a separate base portion containing the base-mark in negative, and four removable smooth slats for the walls (Foy and Nenna 2006; for an excellent discussion of the problems involved in interpreting the meaning(s) of the base-marks see Taborelli 2006; on extant moulds and their mode of use see Amrein and Nenna 2006.) Not only were prismatic bottles blown in moulds, but cylindrical bottles too.

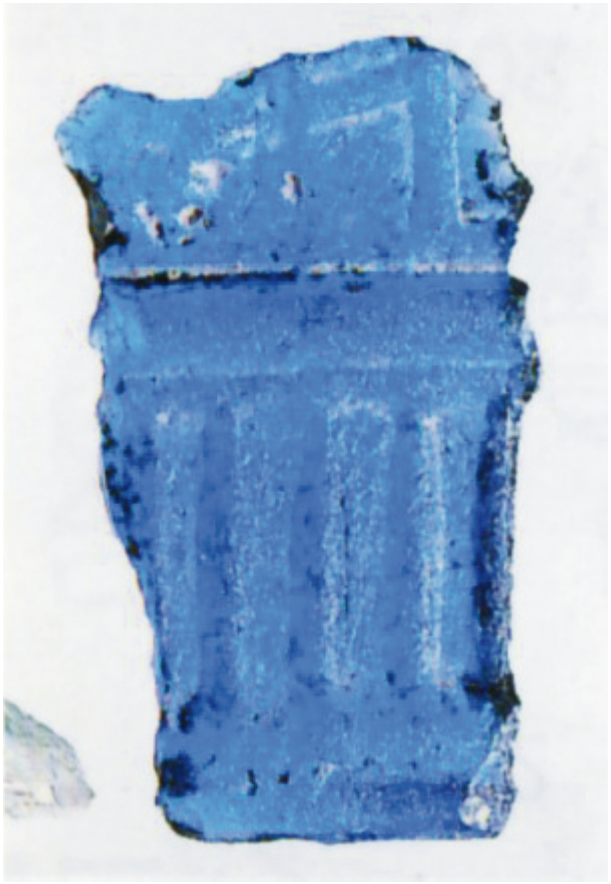

Fig. 7.13: Fragment of translucent deep blue mould-blown cup (skyphos) preserving the lower left corner of a tabula ansata at the top right framing the glassblower's signature. From a late Augustan context (before AD 14) at Magdalensberg, Austria. After Czurda-Ruth 1998, pl. 2, no. 782. Height of fragment 3.5cm. (By permission).

Inventions in Rome

Pliny's remarks on the manufacturing techniques for which Sidon had been famous in the first quarter of the 1st century AD and earlier are complemented by Strabo's remarks on technical improvements in the West: 'At Rome, also, it is said that many inventions are made, both for producing the colours and for facilitating production techniques, as for example of wares resembling rock crystal; thus one can buy there a [glass] bowl or drinking vessel for a copper.' (Strabo, *Geography* 16.2.25; translation by the author).

Strabo lived into his eighties. The improvements in Rome must have coincided with Sidon's years of fame, since he died in 23/24 AD, the year in which Pliny was born. He wrote at least part of his *Geography* while he lived in Rome (Radt 2001, 1022), but although the phrasing of 16.2.25 implies the improvements were recent at the time of his writing, the text does not suggest he got his information in the city. Strabo concentrated his remarks on glassmaking in the chapter on the Syro-Palestinian coast. The improvements in Rome follow reports on primary glassmaking at Sidon and in Egypt where Strabo lived from about 25/24 BC perhaps until 20 BC and actually spoke with glassmakers in Alexandria.

Archaeological evidence suggests the new colouring techniques were invented in the early Augustan period. The colours were obtained by adding metal oxides. Certain colours appear to have been achieved with an unusual glass composition based on the addition of plant ashes (Thirion-Merle 2005, 42). The improved colouring techniques set off an entire industry of

counterfeiting. Pliny (*HN* 37.199–200) explains at length how to distinguish counterfeits from precious stones.

Numerous glass vessels dating from the last quarter of the 1st century BC and the first half of the 1st century AD illustrate the wide range of brilliant colours achieved in Rome. The names modern scholars have given to early imperial glassware are revealing: strongly coloured monochrome glass, translucent and opaque fine wares, cameo-glass, colour-band glass, gold-band glass, reticella or network glass, and various classes of polychrome mosaic glass. All these wares were characteristic luxury products of workshops in Italy, many of which were probably located in Rome. The vivid colours are so characteristic that they have become an important criterion for proposing a western origin for similar vessels excavated occasionally in the East.

If the new colouring techniques in Rome have been associated correctly with the early Augustan period, they were invented at around the time when 'glass pottery' techniques are believed to have become known in Rome (see above). Combined with the improvement of eastern Mediterranean production techniques, the new recipes for colouring played a significant role in the success of the nascent (western) Roman glass industry. Mosaic glass and other hot-formed vessels imitated precious stoneware made from banded agate and fluorspar, but the main attraction of the glass vessels was their ability to improve upon nature. By manipulating the veining of their products glass-workers could 'surpass' both colours and patterns of precious stones (Fig. 7.14). Brilliant colours and polychrome patterns evoking and improving upon precious and semiprecious stones also remained a characteristic of early blown glass produced in the West (see Figs 7.5, 7.7, 7.8, 7.9). Even the colourless glass that became fashionable for tableware in the last quarter of the 1st century AD imitated a precious stone, rock crystal.

By contrast, Syro-Palestinian glass artisans did not try to vie with 'stoneware'; whether this was due to a lack of know-how or to a different taste, we do not know. Instead, artisans in that part of the Roman Empire concentrated on mould-blowing and reproducing the embossed relief decoration of silver vessels. The transparent pale blues and yellowish browns of glass tableware with designs in low relief evoked silver and gold. These colours were achieved without the addition of metal oxides; they depended upon the amount of oxygen in the furnace while the glass was melted (Brill 1988, 269–274). Small mould-blown scent bottles decorated with high relief were often opaque white, less frequently another opaque colour. However, these monochrome opaque bottles do not evoke precious stone vessels. The main reason for using opaque glass appears to have been that the opacity enhanced the readability of the decoration in high relief.

Fig. 7.14: Striped mosaic glass bowl, parallel row pattern. Said to have been found in Italy. Late 1st century BC to early 1st century AD. Toledo Museum of Art. Purchased with funds from the Libbey Endowment, Gift of Edward Drummond Libbey, 1968.87. H 5.6cm; rim diam. 8.4cm. (Photo Richard Goodbody, by permission)

The grammar of Strabo's phrasing suggests he associated the low price of glass cups in Rome with the inventions related to colouring and decolourising the material (more on this subject in Stern 2007, Section 5). His association of colourless glass with a low price is surprising to say the least. Throughout antiquity decolourised glass was regarded as a costly item of luxury. Pliny's remark on the price of colourless glass is of special interest in this connection: 'Glassware has now come to resemble rock crystal in a remarkable manner, but the effect has been to flout the laws of Nature and actually increase the value of the former without diminishing that of the latter.' (Pliny, *HN* 37.29; translation Eichholz 1962, 185).

The evidence of the emperor Diocletian's *Price Edict*, issued in AD 301, makes Strabo's remark even more mysterious, because by that time, colourless glass is no longer associated with Rome and the West, but with Egypt. In the *Price Edict* 'Alexandrian glass' has become the generic name for all high quality colourless glass (Giacchero 1974; for an updated discussion of the *Price Edicts* section on glass see Stern 2007, Section 8).

General trends in the use of glass in East and West

Diocletian's *Price Edict* brings us to the 4th century AD. By that time, Alexandria had replaced Rome as the producer of high quality colourless glass, and the Syro-Palestinian area surpassed the West in output and variety of all types of vessel glass. Unlike the 1st century AD, when

vessel glass was much more varied and used more commonly in the West than in the East, in the 4th and early 5th centuries AD glass vessels served many more functions in Syro-Palestine than in the West, and they were used by a much larger segment of the population (for scholarly discussions of late Roman glass from the Syro-Palestinian coast see Arveiller-Dulong and Nenna 2006; Israeli 2003; Stern 2001).

Glass tableware often had similar shapes in the East and West, but the shapes of glass vessels serving other functions differed considerably. Fig. 7.15 shows a selection of characteristic late Roman vessels from Israel enhanced with applied thread decoration. The pear-shaped flask is decorated with indented blue trails on either side of the body, each continuing up the neck to form three ornamental handle loops. One of the two spherical jars has handles and blue zigzag decoration (note the typically eastern cut-out collars in the rims of both jars). The kohl tube with two compartments for black eye paint is a typical Palestinian shape (on the contents of kohl tubes, see Blanchard *et al*. 1992). The footed bowl belongs to the blue zigzag group. A cosmetics bottle with a metal applicator-rod lies in the foreground.

Fig. 7.15 Late Roman glass vessels decorated with applied threads. Excavated in Israel. 4th to early 5th century AD. After Gorin-Rosen 1998, p. 23. (Photo Israel Antiquities Authority, by permission)

Numbers of vessel forms available in East and West

As mentioned above, the use of glassware in the West appears to have started with a variety of forms in widespread use. Here, the second half of the 1st century AD was the most prolific in terms of quantity, variety of forms, and variety of functions of glass vessels. Hilary Cool and Jennifer Price (1995, 223) published a table showing the numbers of vessel forms from Colchester grouped by likely function (Table 7.1; see also Cool and Baxter 1999). The patterns detected at Colchester reflect a trend in patterns of use that was broadly similar across the western part of the Roman Empire.

In the 1st century, glass vessels served a large variety of purposes: tableware, storage and transport of solids and liquids, personal use (e.g. for cosmetics, scents, bath oils, and medicines), as well as various scientific and other purposes. For some unknown reason the functions served by glass declined during the 2nd to 4th centuries. By the 4th century almost all the glass made in the north-west provinces was tableware, in particular for drinking and serving liquids.

Period	Drinking vessels	Food presentation vessels	Liquid serving vessels	Storage vessels (liquid and solids)	Other	Total tablewares	Total no of forms
AD 43–100	11	10	7	13	3	28 (64%)	44
AD 100–230	7	4	7	20	–	18 (47%)	38
AD 230–400+	10	4	13	5	1	27 (82%)	33

Table 7.1. Roman glass vessel forms at Colchester, grouped by likely function (adapted from Cool and Price 1995, 223, Table 13.1).

Period	Drinking vessels	Food presentation vessels (bowls, jars, dishes)	Liquid serving vessels	Storage vessels (liquids and solids)	Other	Total tablewares	Total no of forms
1st–2nd century	4	13	3	41†	4	20 (31%)	65
3rd–early 5th century	22	50*	46	48‡	7	118 (68%)	173

Key: * includes 20 jars, † includes 37 forms of unguentaria, ‡ includes 44 forms of kohl tubes

Table 7.2. Palestinian glass vessel forms grouped by likely function (after Stern 1999, 484, Table 3; based on Barag 1970).

The number of forms for jugs and flasks remained approximately unchanged from the 2nd century on, showing a slight increase with respect to the variety available in the 1st century. There were fewer forms of drinking vessels to choose from, but there is no evidence to suggest that the actual number of drinking vessels decreased. On the other hand, the reduced choice in dishes for serving foods does seem to coincide with a decrease in use of glass for this purpose.

Beginning in the 3rd century the forms of glass storage vessels for solids and liquids became less varied. In the 4th century, the demand for variety in drinking vessels increased sharply. From then on, drinking vessels were to remain the vessels with the largest variety in forms throughout Frankish (Merovingian) and medieval times and drinking was to be the main function of glass vessels, so much so, that ‘glass’ is nowadays the generic word for drinking vessel.

With regard to the diversity of forms serving one function, the situation in Syria and Palestine developed in an opposite direction to that of the West. The general trends in glass use and glass production which led to this are reflected in the number of vessel forms available for specific functions. The forms and functions of vessel glass represented in assemblages from the eastern Mediterranean have not yet been analysed, but some general observations can be made, albeit with the reservation that the conclusions are preliminary and will need to be adjusted when detailed analyses of individual sites become available.

Table 7.2 shows the numbers of vessel forms from Palestine grouped by likely functions. The numbers are based on a rough count of the individual forms given by Dan Barag in his unpublished thesis (1970). I did not count decorative variations within one shape, or forms that are known from subsequent excavations in Israel but not included in Barag's thesis. For the 1st and 2nd centuries he described 13 forms of bowls and dishes for serving food, 4 forms of drinking vessels, and 3 forms for serving liquids, *i.e*. a total of 20 forms of tableware. There were also 4 forms for storage and/or transportation, 37 forms of unguentaria and 4 miscellaneous forms.

In the 3rd to early 5th centuries about 30 individual forms were available for serving food in bowls and dishes (not including 20 Palestinian forms of jars which may or may not have been used as tableware), 22 forms of cups and beakers and 46 forms of jugs and flasks for serving liquids, *i.e*. a total of 98 tableware forms (or 118 if the jars are included). There were also 44 forms of kohl tubes and 7 miscellaneous forms, including 2 forms of lamps and 1 form of spouted bottle (identified as a breast pump by Rouquet 2003). There was little variation in forms for bulk storage: perhaps 4 forms, probably less, were available. These numbers do not include typical Syrian forms such as sprinklers.

Conclusions

Pliny's statement (*HN* 36.198) that 'there is no other material nowadays that is more adaptable (than glass)' was no exaggeration. Glass was the most versatile material known to the Romans. Its ability to imitate to perfection the colouring, shape, and decoration of objects made in other materials such as pottery, metal and stone remained unparalleled until the invention of plastics and other polymers in the 20th century.

The archaeological evidence supports Pliny's claim that the three most important glass production techniques of the Roman Empire, blowing, tooling on a turntable, and mould-blowing originated in the East. In the Augustan era, the techniques of blowing and tooling were transferred to Rome and subsequently perfected in the West. Techniques, tools, and equipment were improved to such an extent that glassblowing is now regarded as one of the most significant achievements of the Roman Empire.

Decorative mould-blowing had a different fate. Artisans in the East explored the intricacies of the multi-part mould. This technique became widely practised in the West only after the mid-1st century. Artisans in the West simplified mould construction: two-part moulds became the norm (with many exceptions, of course). The great western contribution to mould-blowing was the invention of the smooth-walled mould for mass production of utilitarian containers, an innovation which however brought on the demise of decorative mould-blowing.

Inventions in Rome were related not only to production techniques but also to the chemistry of glass. Strabo's remarks about technical improvements in Rome are borne out by early Roman luxury glass such as mosaic glass and fine blown tableware. The glowing colours and carefully manipulated patterns of these vessels surpassed the colours and veining of precious 'stoneware'.

While the 1st century AD represents the acme of glass production in the West, it is the late Roman period that was most prolific in the East. The diversity of individual forms in use in Syria and Palestine reached its peak in the 4th and early 5th centuries and was unrivalled elsewhere in any other period of history. The reasons for these opposite trends in the patterns of glass production and glass use in East and West have yet to be fully explored.

Acknowledgements

My thanks are due to the organisers of the symposium in honour of Jennifer Price (14–15 March, 2006) for inviting me, and in particular to Ian Freestone for suggesting the topic of this paper. Of all colleagues currently active in glass research, Jenny is the one I have known longest. We met ages ago in the study room at the British Museum where we discovered that we were both working on a PhD in ancient glass. Jenny had a degree in law and I was teaching Latin and Greek. In the years that followed Jenny became a leading scholar in the field, perhaps THE leading scholar, publishing finds excavated at numerous sites within and beyond the frontiers of the Roman Empire.

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Section 2: Vessels and their Forms

8

MOULD-BLOWN BEAKERS WITH FIGURATIVE SCENES: NEW DATA ON *NARBONENSIS* PROVINCE

Souen Fontaine and Danièle Foy

Mould-blown glass with figurative scenes, in particular those showing gladiatorial combat or chariot racing, is one of the earliest glassware to have aroused scholars' interests. Among the numerous studies on the subject, those of D.B. Harden (for example 1958 and 1982) and Jennifer Price (in particular 1974; 1991; 1995) have widely contributed to the knowledge of this exceptional, decorated tableware of the first century AD.

Beyond the interest that they represent for the history of glass, these objects constitute a fount of accurate information on the architecture and fixtures of public buildings – amphitheatres and circus' – and on the various equipment used for the *munera* – combat of gladiators – and for chariot racing (see Ville 1964, Landes 1998). Produced during the second half of the 1st century AD, and essentially found in the north-western provinces of the Empire, these vessels bear witness to the diffusion of the Roman way of life and of imperial propaganda in the western provinces.

Less common are beakers with mythological scenes, which are said to have been produced in the east of the Roman Empire (Wight 1990; Price 1991, 72–73). Most of the pieces published belong to collections comprising objects coming from eastern Mediterranean sites (e.g. Weinberg 1972; Wight 1994; Stern 1995).

The re-examination of past documentation and new studies on glass from the Roman province of *Narbonensis* permit an update of the corpus of mould-blown glass tableware with figurative scenes. Presented here are some new data on the 'so-called' sports cups and mythological beakers found in the south of France.

Sports Cups

Among all glassware with figurative scenes found in the Western Roman Empire, sports cups are the most common (Tables 8.1 and 8.2). The large number of known pieces permits classifying them according to different criteria such as shape and iconographic design; two typological studies, done in the same way, are available. The first, constructed of objects discovered in Switzerland, was published in 1988, under the direction of B. Rütti (Rütti *et al*. 1988). The second, directed by G. Sennequier and comprising objects found in France, was published ten years later, in 1998 (Sennequier 1998). At the time of Geneviève Sennequier's

publication, the *Narbonensis* province appeared to be quite a deficient region, with only 15 known cups (Sennequier 1998, 83) compared to 38 from *Lugdunensis* and 41 from *Aquitania*.

By 1998 beakers with depictions of chariot racing or gladiator tournaments had been identified in *Narbonensis*, excavated from different sites along the Rhône Valley, the Mediterranean coast and inland (Figs 8.1 and 8.2). The best-preserved cup came from Montagnole (Fig. 8.2). Two other cylindrical cups were known from Orange and Vaison-La Romaine (Fig. 8.2). Both cups, mentioned by G. Sennequier as coming from St-Rémi de Provence (Glanum), had already disappeared at the time of publication, so their style/form and their one or two-piece manufacture cannot be determined. On the coast of *Narbonensis*, three cups are known from Olbia de Provence: a cylindrical one depicting chariot racing and *Venatione* (Fig. 8.2), an ovoid one (Fig. 8.2) and a conical one. From Fréjus another conical cup (Fig. 8.2) was found. Two cylindrical cups from Lattes (Fig. 8.2) and two very small fragments from Vendres are also known. The west part of Provence has three cups from Toulouse (Fig. 8.2) and three small fragments of a cup from Cazères. The fragment of chariot racing cup found in a pit of the Agrippa Camp in the area of Aiguières should also be mentioned. This was published by Jennifer Price in 1988 (Price 1988), but not integrated into the typology of Sennequier (1998). This fragment has recently been republished in the complete study of the site (Cottam and Price 2009). None of these sports cups had been published before Sennequier's *Scene de Spectacles* in 1998, except that from Montagnole, one from Toulouse, one from Fréjus and one from Orange.

Shape	scene	Inscription	Color	Site	Publication	Fig.
cylind. B1?	Circus element Chariot racing	[…]CAS[…]	light blue	Peyrestortes	unpublished	Fig. 7
cylind. B1?	Circus element Chariot racing		light blue	Peyrestortes	unpublished	Fig.7
cylind. B4	Circus element Chariot racing	CECASVA[..]RAM	light blue	Toulouse	Spectacle 1998, no.19	Fig. 2
cylind. B4	Circus element Chariot racing	[…]A.PYRAM[…]	light blue	Vaison-la-Romaine	De Kisch 1972 Spectacle 1998, n°20 Foy, Nenna 2001, n°286	Fig.2
cylind. B6	Circus element Chariot racing		light blue	Toulouse	unpublished	Fig.8
cylind. B6	Circus element Chariot racing	[…]XANTEVA[…]	colorless	Orange	Sternini 1991, no.535 Spectacle 1998, no.23Foy, Nenna 2001, no.287	Fig.2
cylind. B11	Circus element Chariot racing		amber	Olbia	Fontaine 2006, no. 399 Spectacle 1998, no.30 Foy, Nenna 2001, no.288	Fig.2
cylind. B	Circus element Chariot racing		light blue	Golfe de Fos	Foy, Nenna 2001, no.289	Fig.3
cylind. B	Chariot racing		dark blue	Vaison-la-Romaine	Foy, Nenna 2001, no.290	Fig.3
cylind. B?	Circus element Chariot racing		blue-greenish	Cazères	Spectacle 1998, no.36	Fig.2
cylind. B	Circus element		unknown	Vendres	Spectacle 1998, no.44	Fig.2
cylind. B	Circus element		unknown	Vendres	Spectacle 1998, no.45	Fig.2
cylind. B	Chariot racing		bluish	Fréjus-Poiriers	unpublished	Fig.8
cylind. C1	Gladiator	[…]TRAITES PRVDES PR[…]	blue-greenish	Golfe de Fos	Foy, Nenna 2003, no.67	Fig.3
cylind. C1		[…]PICVLVSCO[…]	olive green	Toulouse	Spectacle 1998, no.62	Fig.2
cylind. C1-2	Gladiator		blue-greenish	Toulouse	Spectacle 1998, no.65	Fig.2
cylind. C3	Gladiator	[…]DES[…]	blue-greenish	Lattes	Spectacle 1998, no.71 Foy, Nenna 2001, no.293	Fig.2
cylind. C3	Gladiator		unknown	Lattes	Spectacle 1998, no.72	Fig.2
cylind. C3	Gladiator	unreadable	amber	Golfe de Fos	unpublished	Fig.4
cylind. C3	Gladiator		amber	Golfe de Fos	unpublished	Fig.6
cylind. C5	Gladiator	[…]OCVL[…]	dark blue	Golfe de fos	Foy, Nenna 2001, no.294	Fig.3
cylind. C	Gladiator	[…]OLVMBVS CALAMV[…]	yellow-greenish	Marseille	Clerc 1929, Pl 4 Foy, Nenna 2003, no.68	Fig.3
cylind. C1-C5	Gladiator		blue-greenish	Narbonne -Castellou	unpublished	Fig.8
cylind. C1-C5	Gladiator		blue-greenish	Fréjus-Porte d'Orée	unpublished	Fig.8
cylind. C1-C5 or D	Gladiator		light blue	Olbia	Fontaine 2006, no.730 mentioned in Foy, Nenna 2003	Fig.3
cylind. D2	Gladiator	GAMVS CALAMVS / TETRAITES SPICVLVS MEROPS HERMES / PRVDES COLVMBV	amber	Montagnole	Spectacle 1998, no.78	Fig.2
cylind.	Gladiator ?	unreadable	blue-greenish	Arles	Foy, Nenna 2001, no.301	Fig.8
cylind. D	Gladiator		light blue	Golfe de Fos	Foy, Nenna 2001, no.295	Fig.3

Table 8.1: Cylindrical Sports Cups in Narbonensis

Shape	scene	Inscription	Color	Site	Publication	Fig.
ovoïd G2	Gladiator	STVDIOSVS	emerald green	Fréjus	Spectacle 1998, no.85 Foy, Nenna 2001, no. 296	Fig.2
ovoïd G/H1	Gladiator Venationes	SPICVLVS COLVMB[…] PETRAIT[…]	blue-greenish	Olbia	Fontaine 2006, no. 397 Spectacle 1998, no. 96 Foy, Nenna 2001, no.298	Fig.2
ovoïd G2 ?	Gladiator	[…]M[…]	blue-greenish	Olbia	Fontaine 2006, no. 398 Spectacle 1998, no.97 Foy, Nenna 2001, no.297	Fig.2
ovoïd G, H, I	Venationes		blue-greenish	Fréjus	Price 1988, p. 30, fig. 23	Fig.2
ovoïd J	?		dark blue	Arles	Foy, Nenna 2001, no.299	Fig.3
ovoïd	?		amber	Olbia	Fontaine 2006, no. 400 mention in Foy, Nenna 2003	Fig.3
non id.	unknown		unknown	Glanum	Spectacle 1998, no.90 disap.	
non id.	unknown		unknown	Glanum	Spectacle 1998, no. 91 disap.	

Table 8.2: Ovoid Sports Cups in Narbonensis

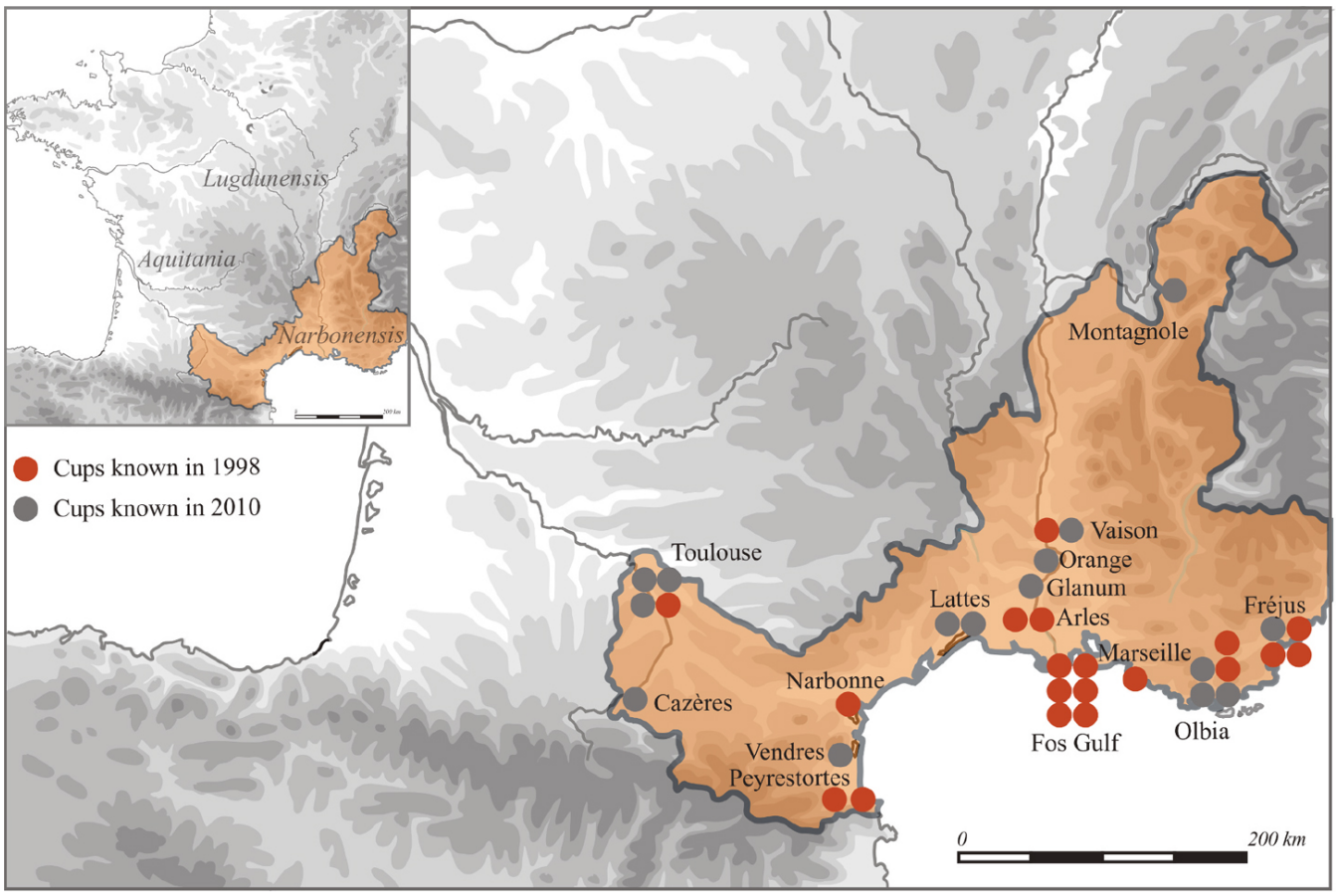
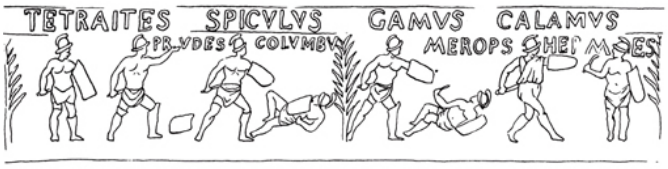
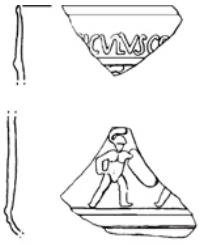


Fig. 8.1: Distribution of the Sport Cups known from Narbonensis.

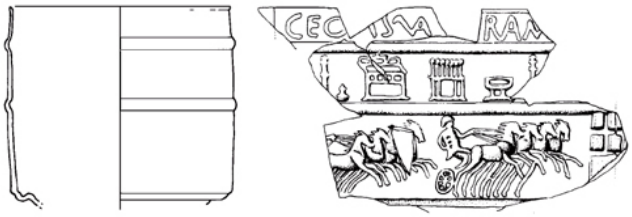


Montagnole (Spectacles 1998, n°78)

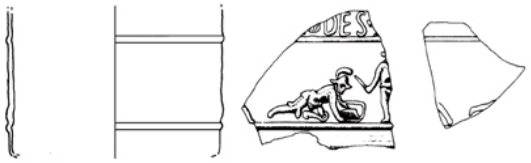
Cazères
(Spectacles 1998, n°36)



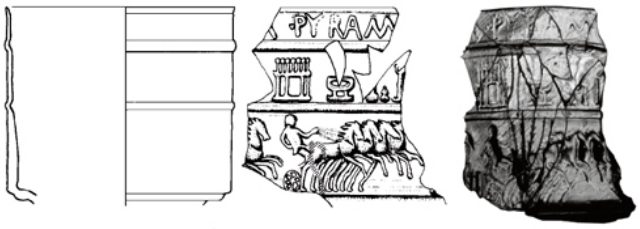
Toulouse
(Spectacles 1998, n°62, 65)



Toulouse (Spectacles 1998, n°19)



Lattes (Spectacles 1998, n°71, 72)

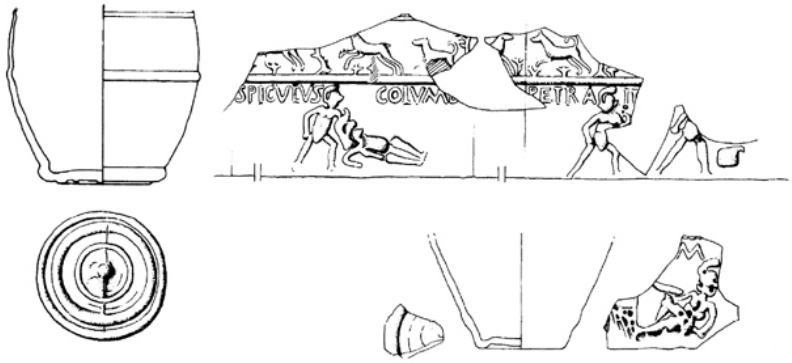


Vaison (Spectacles 1998, n°20)

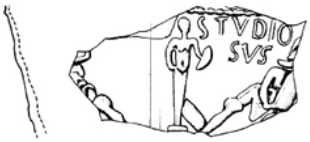
Orange (Spectacles 1998, n°23)

Vendres
(Spectacles 1998, n°44, 45)

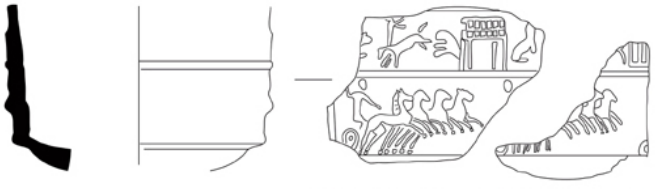
Fréjus (Price 1988)



Olbia (Spectacles 1998, n°96, 97)



Fréjus (Spectacles 1998, n°85)



Olbia (Spectacles 1998, n°30, dessin S-D. F.)

Fig. 8.2: Sport cups from Narbonensis known in 1998 (Sennequier 1998; Price 1988).

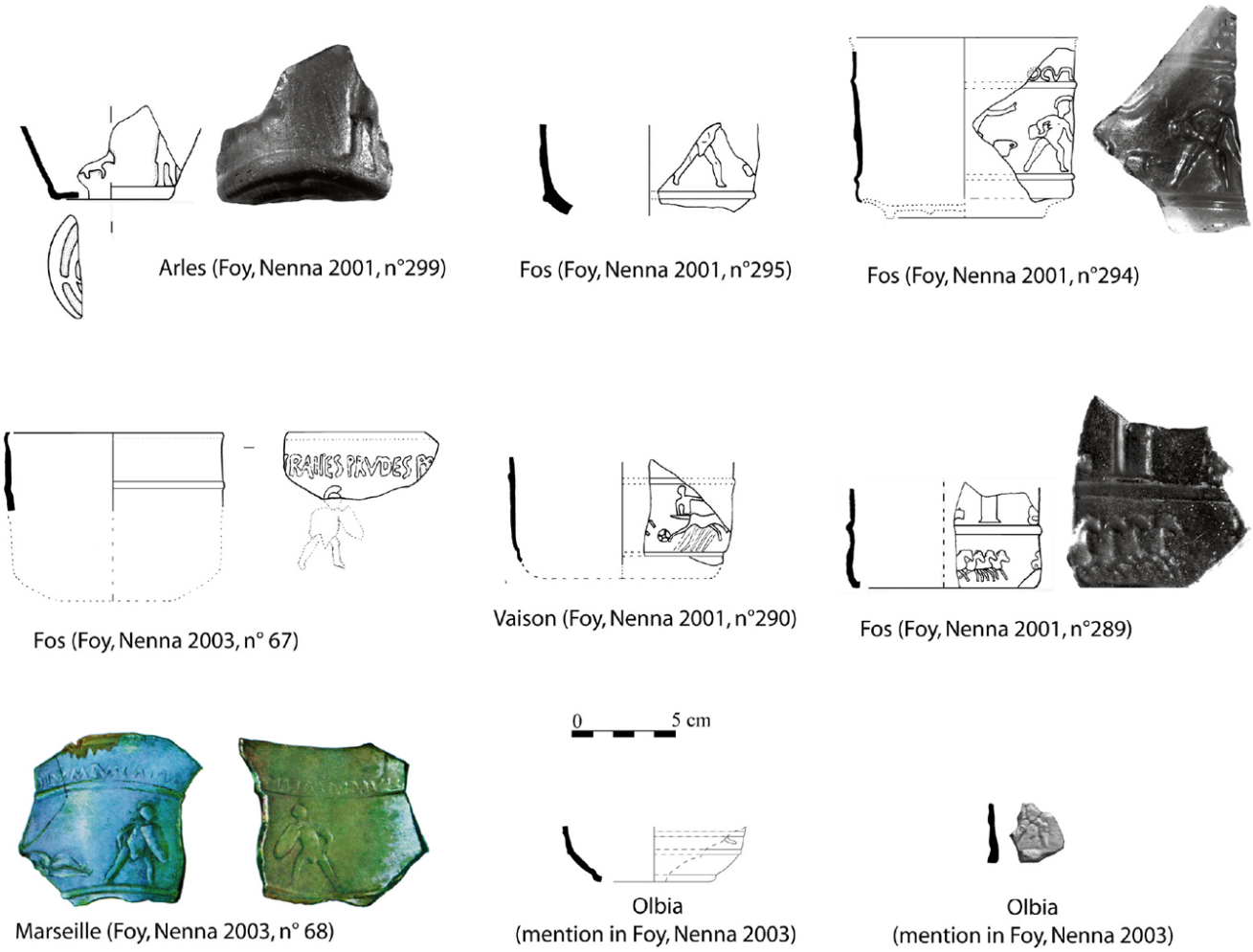

Arles (Foy, Nenna 2001, n°299)
Fos (Foy, Nenna 2001, n°295)
Fos (Foy, Nenna 2001, n°294)
Fos (Foy, Nenna 2003, n° 67)
Vaison (Foy, Nenna 2001, n°290)
Fos (Foy, Nenna 2001, n°289)
0 5 cm
Marseille (Foy, Nenna 2003, n° 68)
Olbia
(mention in Foy, Nenna 2003)
Olbia
(mention in Foy, Nenna 2003)

Fig. 8.3: Sport cups from Narbonensis known in 2003.

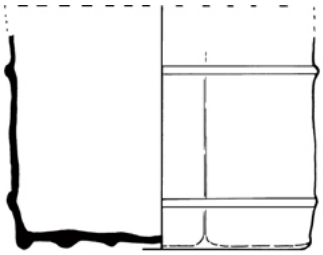
Since the publication of that volume, a larger study has been researched and published on the glass of *Narbonensis* for the exhibition "*Tout Feu, Tout Sable*" in 2001 and its associated congress (Foy and Nenna 2001; 2003). This research has uncovered or re-discovered a quantity of mould-blown glassware with figurative scenes. Nine new sports cups were published or mentioned (Fig. 8.3). Those found include a new sports cup from Vaison-La-Romaine, kept at the Calvet Museum in Avignon, a fragment from Arles, a fragment from Marseille (published in 1929 by Clerc) and two from Olbia de Provence. More spectacular was the re-discovery of glass from the Fos Gulf, which showed a great diversity of mould-blown glassware and at least four cups featuring chariot racing or gladiator contests.

Since 2003, the pursuit and development of these regional investigations have enlarged the corpus with nine new elements; bringing the corpus to thirty-three sports cups found in *Narbonensis* Province. Those new fragments, which we present here, have also been integrated into the recent work updating the French typology (Foy and Fontaine, 2010).

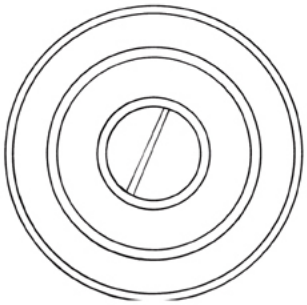
Fos Gulf

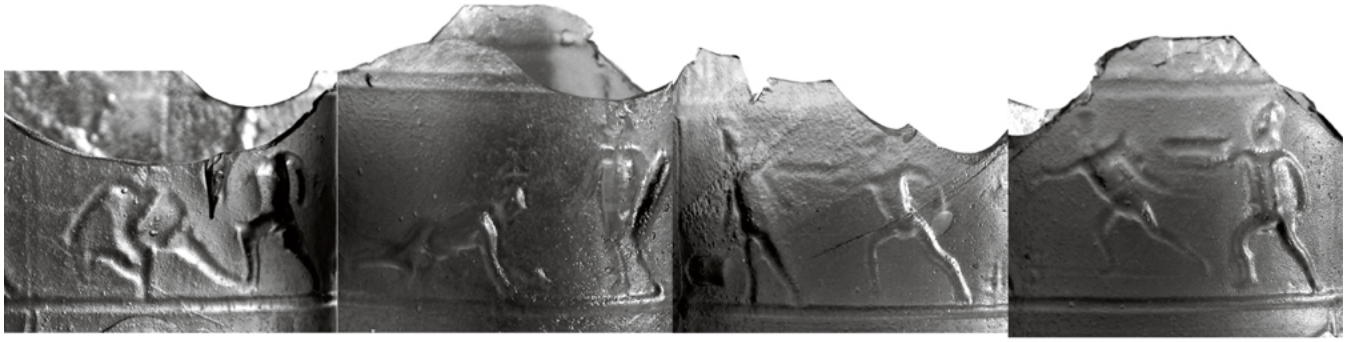
Two of these cups come from the underwater context of Fos Gulf, which is considered by many to be an important harbour deposit (see Liou and Sciallano 1989) although the stratigraphy is not very clear and the site has never been professionally excavated. Divers

have brought up archaeological material without having precisely documented its location, although most is taken from different areas of the same context. The site's occupation is dated from the 1st to the 3rd century AD; a large part of the glassware (as amphoræ and ceramics) belongs to production of the second half of the 1st century. The whole collection is divided between three different museums and is currently under study for publication. There are already two new cups with gladiator scenes. The most impressive one belongs to the private collection of M. Frederic Lehoussel.



0
5 cm





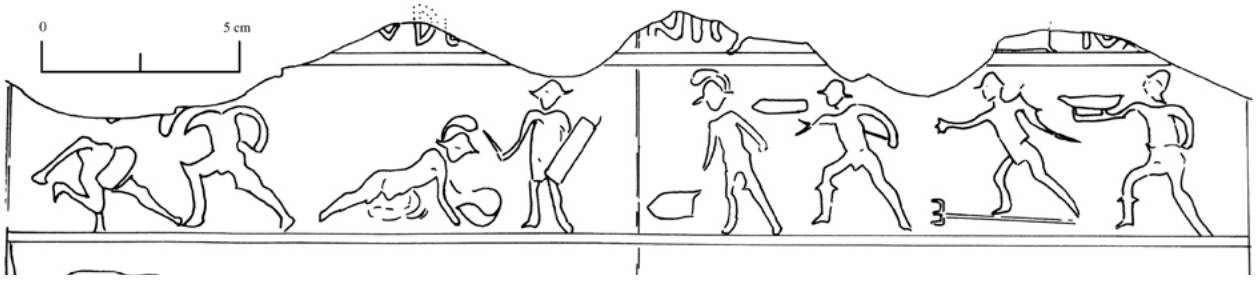
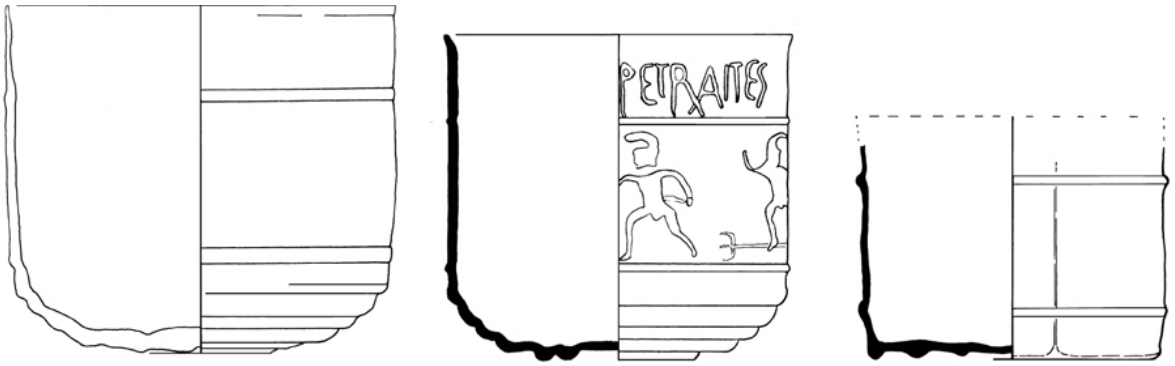

0
5 cm

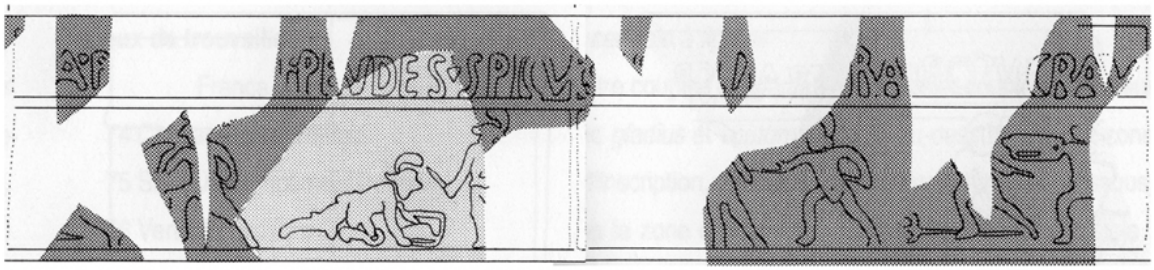
Fig. 8.4: Sport Cups of Golfe de Fos (Collection of Mr Lehoussel. We would thank here Frédéric Lehoussel who allowed us to study this exceptional piece and Martine Sciallono – Conservatrice du Musée d'Istres who informed us about it).



Vindonissa Como Fos

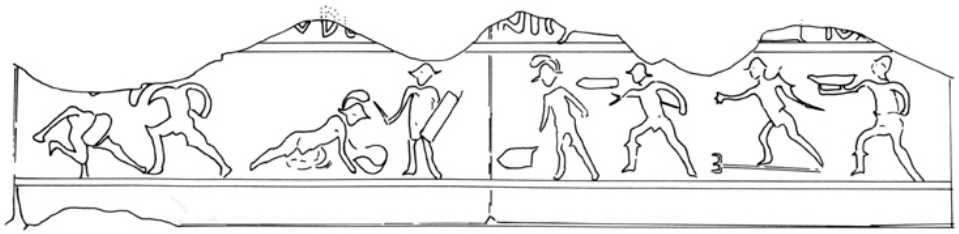
Vindonissa

0 5 cm



Vindonissa (in dark grey) + Lattes (in light grey) (Sennequier et al. 1998)

Como (De bellis 1999)



Fos

Fig. 8.5: Comparison between the fragments from Vindonissa (Sennequier 1998), Lattes (Sennequier 1998) and Como (De Bellis 1999).

This amber/yellow cup (Fig. 8.4) has an almost completely preserved decorated section; however the inscription has almost completely disappeared. As with the cup from Montagnole (found during the XIXth century), this new cup from Fos is the most complete found in the *Narbonensis* Province. The mould marks are clearly visible and the use of a three-part-mould (two parts for the body and a third one for the base) for its fabrication can be established. The relief is particularly clearly defined and the figures are well-modelled. As usual, the iconographic scene is composed of four pairs of fighting gladiators. This scene corresponds to Type C3: identified on the fragments from Vindonissa (Swiss typology: Rütti *et al*. 1988) and Lattes (Gaulish typology, Sennequier 1998) (Fig. 8.5). The beaker from Fos completes the missing part of this type, at least for the figurative scene, and validates the reconstruction proposed by Sennequier (1998). Another cup, published in 1999 (De Bellis 1999), was found in the town of Comasco located in the area of Como in Italy. This cup, totally intact, seems at first sight from the published photograph to belong to the same mould/design as Type C3 and could assist the reconstruction of the missing part of the inscriptions of the Fos and C3 types. But, even if the iconography is similar overall, there are some notable differences. The most remarkable difference concerns the vanquished gladiator of the first pair on the left; he is in a totally different position from the one from Fos. The small fragment from Vindonissa, as far as it is possible to interpret, seems to be closer to Fos than to Como. Furthermore, for each pair of battling gladiators some details vary. The standing gladiator of the second pair from Como has the *scutum (i.e*. shield) in his right hand, whereas those from Fos and Lattes have it in their left hand and hold a sword in their right hand. As for the third pair, the arm position of the defeated combatant is not the same: the hand is up for Como and down for Fos.

These details show that the moulds are different. Consequently, we cannot reinstate the inscription of the C3 mould, or type, from the Como model. Nevertheless, we have confirmation of the restoration of, at least, PETRAITES, for the third pair, who probably fights with COLVMBVS (as on the C3 matrix). The small part of the inscription register conserved on the Fos cup (just above the last gladiator pair) could help us to propose a new reading of the truncated text on the Vindonissa cup. Rütti (1988) reinstated the rest of the inscription as […]CRAV[…], however it can be seen that the C is incomplete. In the inscription area of the Fos cup, the only inscription preserved is a part of a rectilinear symbol consisting of a horizontal line with a small vertical extension (not readable as a letter), followed by a space and then the base of some letters (proposed to correspond to RA). It is suggested that the same rectilinear symbol used between two words is present on the Vindonissa fragment, instead of the C proposed by Rütti.

Moreover, if we look at the shape of both the Como and Fos cups, we notice a profile difference. This means, as far as we know, that the same or very similar iconographic design could be interpreted with some variations on different cup shapes. This observation brings some more issues to the typological study relating to the use, re-use and reproduction of the mould, and underlines the difficulty of defining which mould is the prototype or which a copy. This poses the question: 'Do we have to continue to try to identify the original mould, thus creating sub-divisions of the existing moulds defined in the Swiss typology for every new variant discovered?' Perhaps it would be more useful and less inventive to define large, more encompassing, types which include several variants of an associated iconographic design and/or shape without aspiring to the identification of a mould. In the same way, we should be careful regarding the assimilation of a small fragment to a specific matrix.

A second new, more fragmentary, piece from the same context of Fos Gulf (Fig. 8.6) could also be associated with the C3 type. The only preserved gladiator-pair on this fragment corresponds to the first pair coming from the left of the cup in the Lehoussel private collection and on type C3. The inscription above the gladiators is no longer legible. The fragmentary nature of the piece makes us cautious to include this in type C3. We know of some examples of the iconographic design that associate this identical gladiator-pair with another pair, in particular on a cup found in Spain and published by Jennifer Price in 1974 (Fig. 8.6). If the second new beaker from Fos belongs to the C3 matrix, it would be interesting to underline that (excepting the cup from Vindonissa) three or four other examples have been found close to the Gaulish Mediterranean coast, on sites only some tens of kilometres away.

Peyrestortes

The second context that has yielded new mould-blown glassware with figurative scenes, Peyrestortes, is located in the region of Roussillon, near the Mediterranean coast and the present Spanish border. A large group of glassware has been found from a homogeneous and rich pit, securely dated to the second half of the first century. There were six mould-blown fragments with figurative ornaments among this assemblage (Fig. 8.7), which could correspond to two different sports cups.

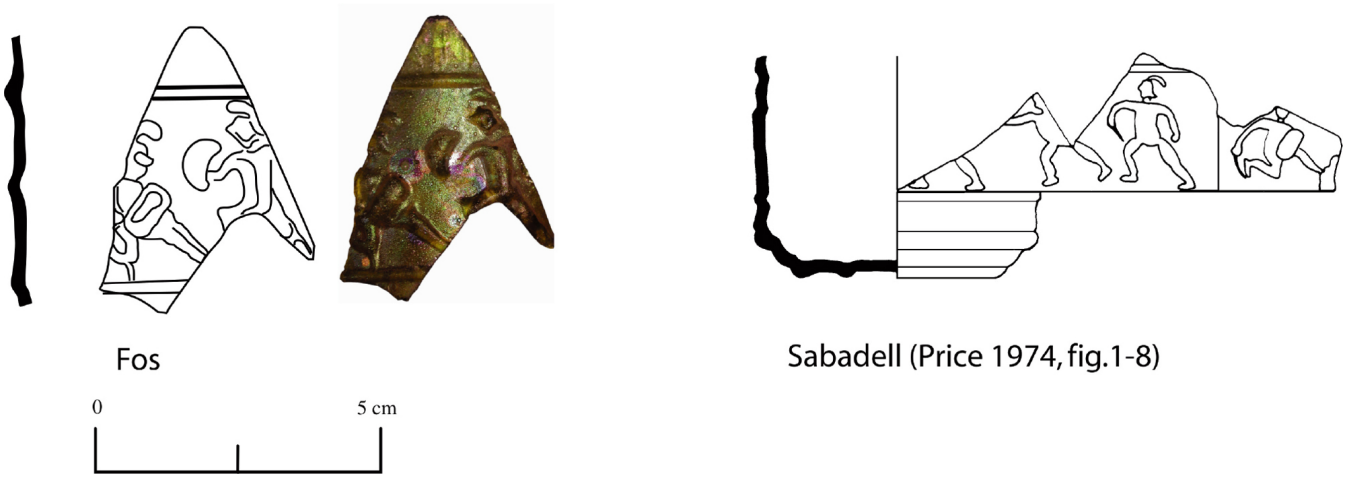


Fig. 8.6: Gladiator cups: Fos and Sabadell (Price 1974).

All the figurative elements may belong to the mould B1 defined by Rütti from fragments from Vindonissa as they have the same architectural and epigraphic elements. A lion figure can be identified on a small fragment from Peyrestortes although the several visible vertical lines in relief under his belly do not appear on the other known lion figures. The fragments from Peyrestortes bring an epigraphical confirmation to Rütti's proposition (Rütti *et al*. 1988 and Sennequier 1998). The cup from Vindonissa left doubt about the reconstruction surrounding GEGAS or CECAS. On the Peyrestortes fragment, we can clearly read […]CAS[…]. This name of CECAS might be a variation of the name of GEGAS, a famous agitator known by an inscription and an illustration on a ceramic lamp conserved in the *Cabinet des Médailles* in Paris.

Narbonne

A small fragment showing two gladiators was found in 2009 in the area of the Narbonne Harbour (Castellou's site, excavated by C. Sanchez (CNRS)). This fragment (Fig. 8.8), mould-blown in a light blue glass, belongs to the C type (possibly to the C1 or C5) and in this case

the victorious gladiator could resemble CALAMUS and the vanquished one, lying on the ground, could be COLOMBUS.

Toulouse

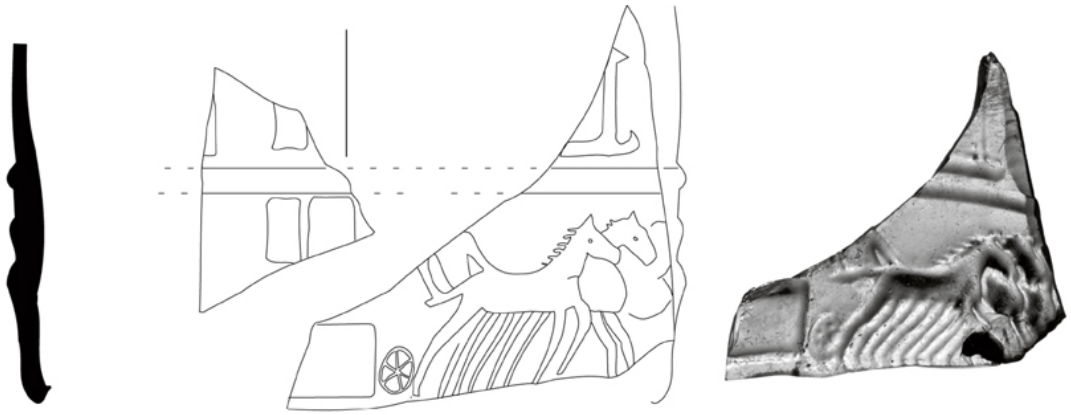
For the three pieces from Toulouse known in 1998, we can add a fourth fragment conserved in the Saint-Raymond Museum and coming from the Quartier Saint-Georges excavation. This bluish fragment (Fig. 8.8) presents two registers; the lower one has kept part of the representation of trees or four horses and of part of a *meta*. It could belong to the Swiss typology B6.

Arles

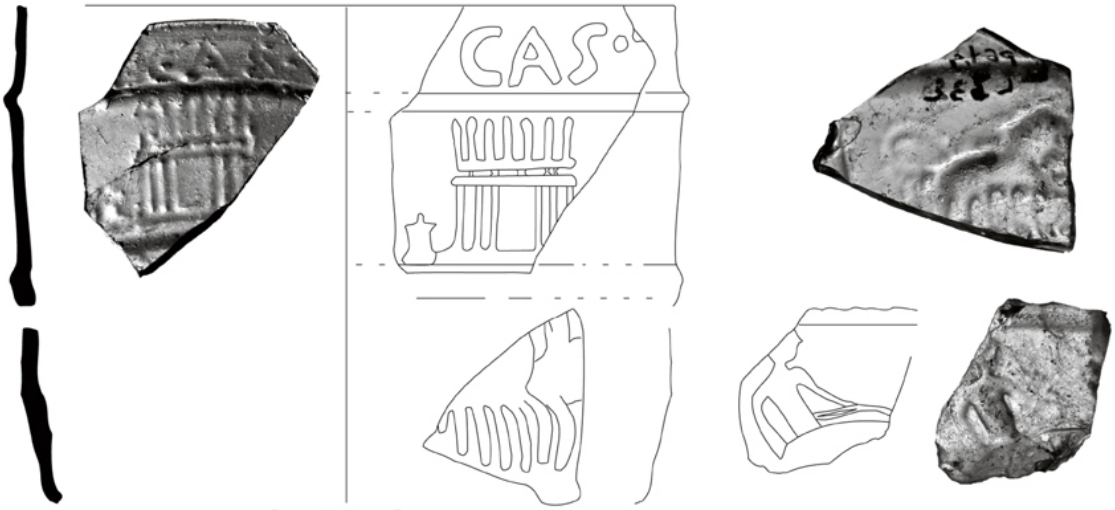
A cup from Arles, found in 1976 during the excavation of the Alyscamps necropolis, was published in 2001 (Foy and Nenna 2001, 181, no. 301), but it was described as not belonging to the group of sports cups (Fig. 8.8). Although the iconographic detail is totally illegible, with a very shallow relief and without a clearly defined shape, it can be seen that pairs of characters side by side or facing each other divide the scene. On the superior register an unreadable inscription or a floral festoon can be seen. The profile is similar in shape to those of the cylindrical sports cups. This combination of elements is rarely found other than on sports cups, even if we know of a few examples of cups similar in shape, but with totally different patterns (e.g. dolphin ornamentation on a cup of Monclus – Musée Départemental de Gap, Foy and Nenna 2001, 181, no. 300). It seems more reasonable to assign the cup from Arles to the sports cups group.

Fréjus

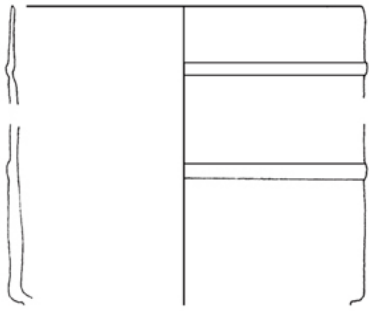
The Roman colony of Forum Iuli offers two new small fragments of sports cups (Fig. 8.8), one coming from the 1980s excavation of Porte d'Orée, an area of the Roman harbour (excavated by by Ch. Gébara (Service du Patrimone de Fréjus)) and another from the rescue excavation of the Poiriers site, an extra-muros thermal area (Excavation by P. Excoffon (Service du Patrimoine de Fréjus)). The Porte d'Orée fragment shows the lower part of two standing gladiators; one hanging the *scutum* on his left side and the other turned to the left with his arm upwards and a *scutum* on the floor near his feet. These two gladiators could resemble, according to the C1 and C5 types, PETRAITES and PRUDENS. On the small greenish fragment found in The Poiriers, parts of three horses from a *quadrigae* are barely preserved; consequently it belongs to the B type.



Peyrestortes A



Peyrestortes B



Mold B1 (Vindonissa + Augst)

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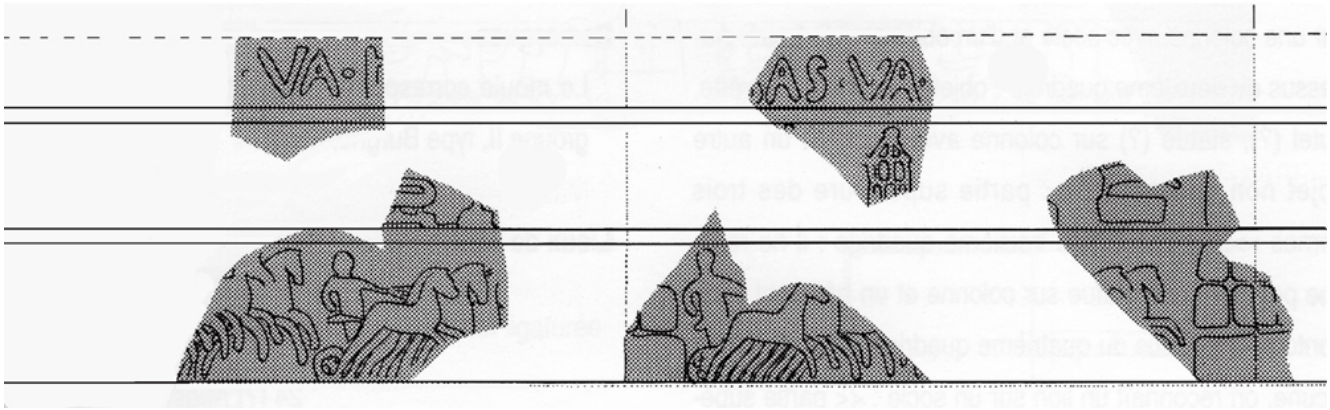


Fig. 8.7: Chariot race Cup: Peyrestortes and Mold B1 (Sennequier 1998).

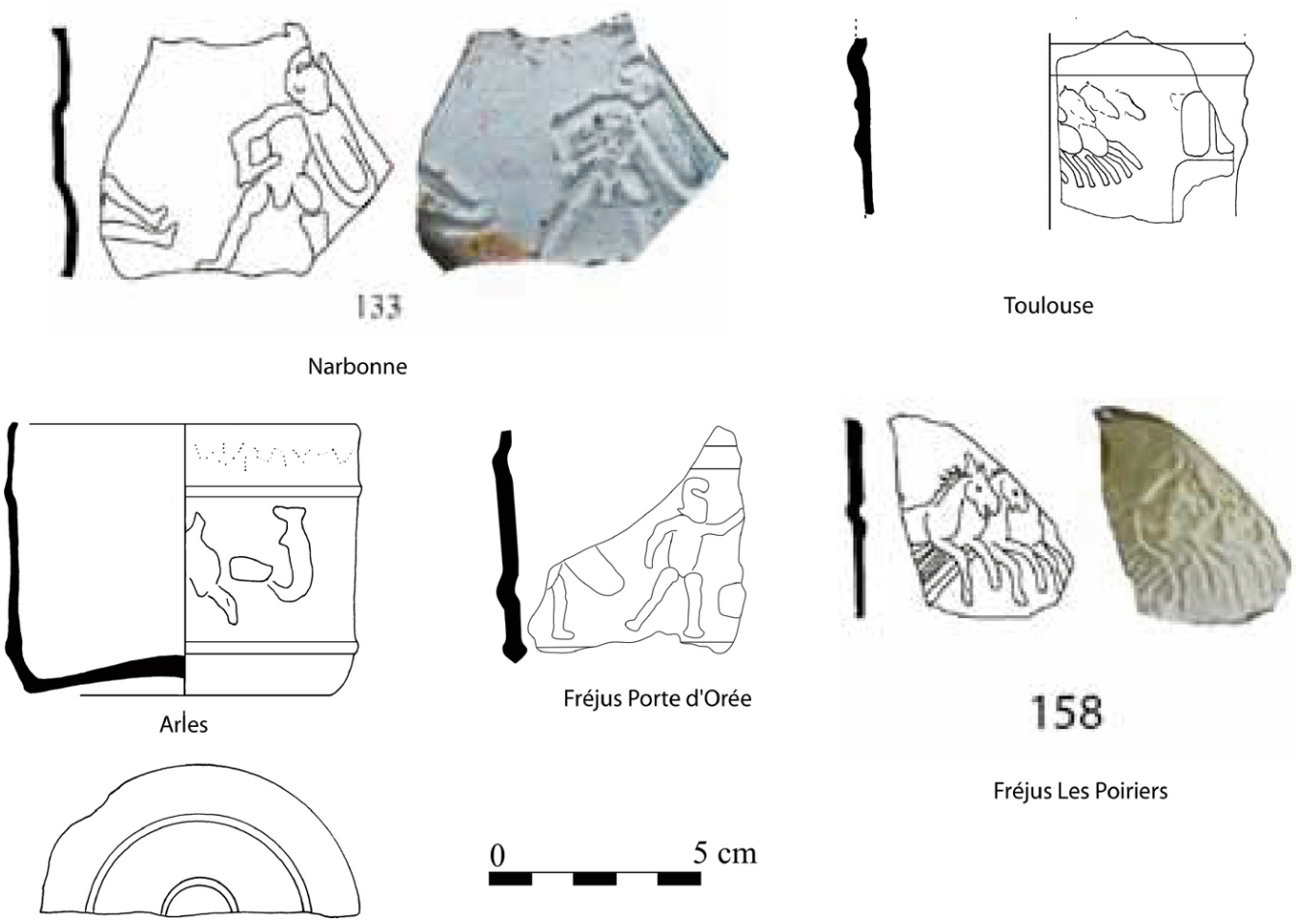


Fig. 8.8: Sports Cups, unpublished.

Mythological Beakers

The second group of mould-blown glassware with figurative scenes, those with mythological figures, has also enlarged during the last decade (Table 8.3).

Before the investigations of 2001/2003 (Foy and Nenna 2001; 2003), only one mythological beaker was known in France. It was found in Burgundy at Nuits-St-Georges (Grosjean 1983, fig. 9; *Autun* 1987, no. 243). In 2003 at least five new pieces were published, four from Fos-Gulf and one from Olbia (Fig. 8.9).

Today, we can cite two new pieces from Olbia de Provence, one from Gignac-la-Nerthe (Gateau 1997), which was briefly mentioned in 2003 (Foy and Nenna 2003), and, probably a least one, not yet studied, from Perpignan (M. Alessandri, pers. comm.). All the pieces belong to the Group II defined by Gladys Weinberg and Karin Wight (Weinberg 1972; Wight 1994; 2000).

Gignac-la-Nerthe

The six fragments coming from Gignac la Nerthe may belong to the same beaker (Fig. 8.10). A half-conserved figure has a small panther sitting at his feet. This association allows

identification of the Young Bacchus from Group II of Weinberg / Wight. The fragment is very similar to the beaker presented by Wight as Group II.4 (Wight 1994, fig. 16).

The fragment showing a head cannot belong to the same character because of its orientation to the right, whereas the legs of the other fragment seem to be turned to the left. This head can be identified as Bonus Eventus. Another small fragment could represent the shoulders and the head in left profile. If this interpretation is correct, the fragment could be associated with the legs of the Young Bacchus. The other fragments are difficult to recognize, although there may be part of a floral ornament and some parts of clothing represented.

Shape	Color	figure	Site	Publication	Fig.
Groupe II	light blue	Hymen	Golfe de fos	Foy, Nenna 2001, no.79	Fig.10
Groupe II	light green	Bonus Eventus or Hymen	Golfe de fos	Foy, Nenna 2001, no.306 (without illustration)	Fig.10
Groupe II	light blue	Dionysos ?	Golfe de fos	Foy, Nenna 2001, no.307	Fig.10
Groupe II	light colorless	vegetal	Golfe de fos	Foy, Nenna 2001, no.308 (without illustration)	Fig.10
Groupe II	light green	Young Bacchus and Bonus Eventus	Gignac	Gateau 1997 mentioned in Foy, Nenna 2003	Fig.10
Groupe II	light blue	Naked legs	Olbia	Foy, Nenna 2003, no.69	Fig.10
Groupe II	light blue	Human figure	Olbia	Fontaine 2006, no. 401	Fig.10
Groupe II	light green	Neptune	Olbia	Fontaine 2006, no.681	Fig.10

Table 8.3: Mythological Beakers in Narbonensis

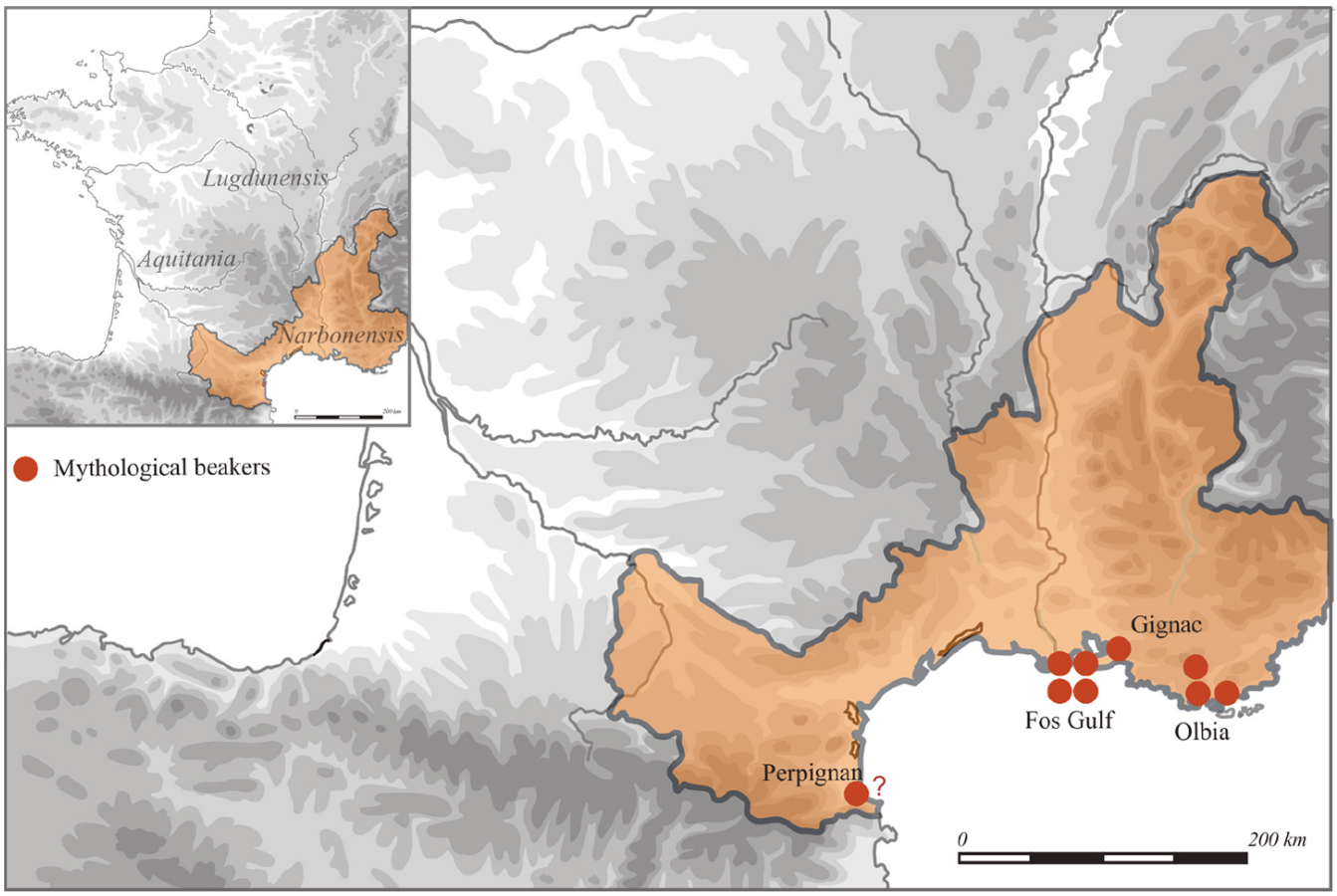
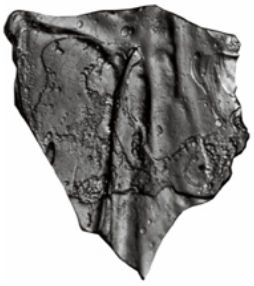


Fig. 8.9: Distribution of the Mythological beakers known in Narbonensis.

Olbia de Provence

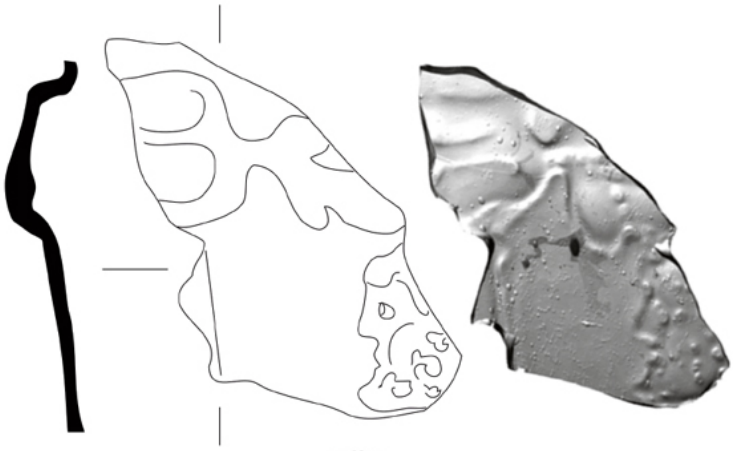
The site of Olbia de Provence has also furnished a fragment of a mythological beaker, published in 2003, with bare legs in a standing posture. From the same context, two new fragments have been identified as belonging to a mythological beaker, probably of Group II. They were distorted by fire and are no longer very clearly identifiable. A third piece was found in Olbia de Provence during the excavation of the 1950s (Fig. 8.10) (Fontaine 2006, 343, no. 401). The fragment depicts a man with a bearded head, in left profile, under a garland of large leaves. The man is in front of one of the four columns that divide the scenes. This figure corresponds to the Neptune of Group II and can be compared with the Neptune shown on a beaker belonging to a private collection and presented as Group II.9 (Wight 1994, fig. 25).



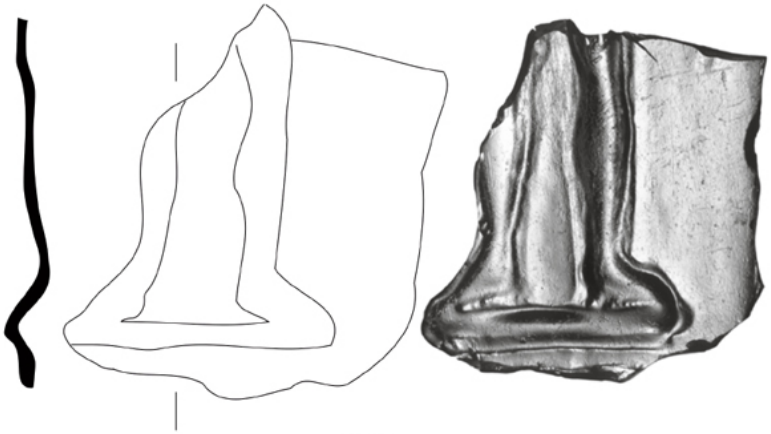
Gignac

Fos

0 5 cm



Olbia



Olbia

Fig. 8.10: Mythological Beakers of Narbonensis

With the new specimens from *Narbonensis* the number of mythological beakers found in France has increased considerably. New discoveries in *Aquitania* Province, in particular those from the military camp of Villeneuve-sur-Lot near Agen (studied by Mr Chabrié), show that their distribution in France, and perhaps in the northern provinces, might be larger than we suppose. This group of beakers, with mythological representations, is said to be produced in the East of the Empire, since the number of examples known in the eastern Mediterranean are greater than in the West. However, with further discoveries the West could provide as many pieces as the East, and the question of the origin of this kind of glassware could be re-visited.

The two particular series of glassware, the sports cups and the mythological beakers, presented here are not isolated cases and the whole body of mould-blown tableware from *Narbonensis* was updated during the international congress of AFAV in Bruxelles in 2008 (Fontaine and Roussel-Ode 2010).

Conclusion

Even if the corpus of thirty-three sports cups from the *Narbonensis* is now closer to what we might expect from this region, there are insufficient numbers to begin a discussion about a possible production area. The rich assembly from the harbour context of Fos Gulf, a transit point between the Mediterranean Sea and the interior, creates an opportunity to ask about the source of trade. Should we consider these beakers as proof of imports from the Mediterranean area (Italy?) or as exports from Gaul or the northern provinces to the north-west Mediterranean coast and inland? At this point in time these questions remain unanswered. If the typological database first established under the direction of B. Rütti in 1988, completed under the direction of G. Sennequier in 1998 and recently updated with new discoveries or rediscoveries from France, was merged with the new data from others in the West-Roman-Empire area (such as Italy, Spain and England), we might then be able to cast new light on the distribution of the group.

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9

ROMAN AND LATER GLASS FROM THE FEZZAN

Birgitta Hoffmann

The Fezzan is a long, roughly east-west facing oasis, nearly 600 km south of Tripoli, Libya. The current capital is Sebha, but around the beginning of the common era the main focus was further west, around Germa/Garama. The comparatively easy availability of water and tradable resources in the area (including potentially large deposits of trona found in the sand sea of Ubari, to the north of Garama, which showed on analysis to be of suitable quality for glassmaking (Freestone pers. comm.), although it is not clear if this material was exploited for making blue glass beads found in large numbers in the Fezzan area) allowed the development of large agricultural systems, and the area's participation in long-distance trade systems. Both developments changed over time and summaries of their history have recently been published (Mattingly 2003).

The unusual glass from the Fezzan was first brought to the attention of Western archaeologists in the publication by Giacomo Caputo, Biagio Pace and Sergio Sergi (Pace *et al*. 1951), reporting on the Italian surveys and excavations in the area in the 1920s and 1930s. In recent decades the Fezzan has once again been the focus of international archaeological attention, and this paper presents some of the finds encountered during the surveys and excavations of Charles Daniels and especially David Mattingly with their respective teams (the detailed reports on the assemblages are now available (Hoffmann 2007; 2010; 2013)).

The known Fezzan material stands at *c*. 2000 fragments (1877 fragments from recent work (Ayoub, Daniels, Mattingly) plus an unknown quantity (approximately 200 fragments) from Italian surveys). The glass material recovered during the recent work comes from a number of different context types, ranging from sites excavated within the old centre of Garama, to the industrial and smaller settlement sites along the wadi, to a number of cemeteries, and was recovered during surface surveys and excavations of various sizes. Predictably, the nature of the material is very diverse and reflects both the original depositional context as well as the mode of recovery, with larger fragments or substantially preserved vessels usually deriving from funerary contexts, while smaller fragments were mostly found in excavations of settlement sites. The assemblage is also dominated by the most well studied sites, such as Garama, the Royal cemeteries and the Sanyat ben Howeidy, which between them account for nearly two thirds of the material. The glass ranges in date from the Hellenistic to the Islamic periods, but is dominated by material from the late 1st century AD to the early Byzantine period.

The material is overwhelmingly made up of open forms, with nearly half of the assemblage coming from bowls or plates and only 2% from jars or unguentaria. Other closed vessels (mainly jugs and bottles) make up 12% of the assemblage (Table 9.1).

Overall it can be said that the glass from the late 3rd century onwards can be paralleled both in type and combination of vessel shapes with glass known from the Western oases of Egypt and the Fezzan and can consequently be understood to be an integral part of the economic sphere of the late Roman Empire and its glass trading mechanisms.

This distribution is still more pronounced when the early Roman glass is differentiated from the later material. Less than 7% of the assemblage can be attributed to jugs and bottles and only 4.5% comes from storage vessels, demonstrating that the use of early Roman glass in the Fezzan is clearly different from its use in the African coastal towns. To cite one example: at Sidi Khrebish/Berenike in the Cyrenaica (Jenny Price in preparation), the two groups reach nearly twice this proportion. There is a marked preference in the Fezzan for certain types of vessels, *i.e.* large cast plates, both in colourless and strongly coloured glass; at Sidi Khrebish for example they are comparatively rare.

Vessel shapes	Total (%)	1-2nd century (%)	3rd-7th century (%)
Bowls or plates	46.00	66.75	27.26
Beakers, cups and lamps	39.70	17.46	60.89
Bottles and jugs	11.55	6.85	14.02
Jars and unguentaria	2.22	4.54	0.00

Table 9.1: Distribution of the vessel types from the Fezzan.

Moreover, the material represents an unusual mix of the highly unusual (large cast plates) and the mundane (square bottles, pillar moulded bowls), but does not show a particularly high concentration of quality tableware. Allowing for the absence of a large number of square bottles and tableware jugs, the material varies little from the types available at a typical northern frontier fort of the same period, but differs markedly from the material available from towns such as Sabratha and the early material from Berenike in the Cyrenaica.

Within the types present, there is a high level of repetitiveness: most of the tubular rimmed bowls are nearly identical in size and design and are made of very similar glass. Both they and the pillar moulded bowls (incidentally not the Eastern style of ribbed bowls, which would be easier to obtain and are present in most of the coastal sites, but more commonly found are the varieties of pillar moulded bowls best known from Italy and Southern France) from the cemetery of Sanyat ben Howeidy are so similar in execution, glass material and size, that they have to be considered as part of the same batch. All of this suggests that in the late 1st and early 2nd centuries AD the glass material arriving at the Garamantes was not sourced at the Tripolitanian or Cyrenaican coast, but arrived as consignments from further away, possibly Italy or (less likely) the north-western provinces.

The absence of really high quality luxury items of the period (e.g. the facet-cut versions of the large plates) suggests that this consignment may not have arrived as part of a high-level diplomatic exchange, but may represent some lower level contact between the two areas. The fact that we see a clear and un-Roman selection of material from a much wider corpus of material available within the Roman empire suggests either that the selection may have been made by someone knowledgeable of local taste or that it was the result of an order by the Garamantes.

After a period of low-level contact in the 2nd century, when little glass was imported, the 3rd and 4th centuries AD are more clearly identifiable in the assemblages. The glass material contains high concentrations of luxury glass, mainly facet and wheel cut (Fig. 9.1 and 9.3), but also painted. A substantial amount of this material was deposited at the Royal Cemetery site, and it is possible that these unusually large concentrations might lead us to overestimate the general amount of wealth invested in glass in the period. Forms clearly parallel those in Egypt and it is clear that from this period onwards the Fezzan was closely tied into the glass distribution network that covered the western oases of Egypt (e.g. Hill and Nenna 2003; Marchini 1999) and to a lesser extent of Cyrenaica (compare Sidi Khrebish, Jennifer Price pers. comm.). Furthermore, the Garamantes were not displaying a similar level of selectivity to that shown in the early Roman period, but appear to be reproducing 'Roman taste'.

In addition, the gold painted beaker (Fig. 9.2) with its excellent parallels in the Sedeinga and Meroe cemeteries (Cool 1996; Leclant 1973) suggests contacts with the Sudan. Cool suggested in the 1990s that the painted flutes from the Sudan, in combination with other vessels, may point towards an independent glass working tradition in Meroe, perhaps based on Roman influence (Cool 1996). This idea has not received universal acclaim, especially amongst scholars working on the Egyptian glass of the period (M.-D. Nenna pers. comm.), and a lot of this research remains to be published. With the exception of the painted glass, however, none of the other types identified by Cool have so far been found in the Fezzan, so this painted vessel may just represent occasional contact with the eastern neighbour and that, on the whole, Egypt formed a more important market/supplier.

Although in Late Antiquity there is a marked drop in the glass quality so far documented, the Fezzan has produced an unusually large number of honey-comb beakers and bottles with abraded designs, suggesting that even at this late period they were able to tap into the Roman/Byzantine trade network. To judge from the small number of late Roman lamps in comparison to other sites, contact may have become either intermittent and/or selective again by this period, a trend that appears to have continued into the early Islamic period when we have evidence for the use of Islamic bottles, but little else.

Fig. 9.2: Fragments of blue glass flute with gold and black painted design imitating Ancient Egyptian art (Germa Museum).

The latest glass finds present are late medieval and early modern glass bangles, and a pseudo-epigraphic glass charm from Germa. Both document the continued use of the site into the 19th/20th century. It seems, however, that unlike Gao on the Niger to the west of the Fezzan oases, the site was not able to obtain the Islamic glass products of the 10th-16th century (Insoll 1998), suggesting a much reduced level of wealth.

Glass use differs markedly within the different cemeteries, but neighbouring graves often seem to share vessels that are visually very similar and may have come from the same batch or, later, the same workshop. This is most apparent with the tubular rimmed bowls and pillar moulded bowls at Sanyat ben Howeidy, and the indented vessels at Ghat, but can also be argued for the vessels with raised decoration and late bottles with abraded decoration from the Royal cemeteries. The reason for these clusters is not clear. In view of the strong indications for an ancestor or at least cemetery cult, it could be argued that some of these vessels represent different burial traditions within a family group, following patterns established by an earlier generation. Alternatively, they could represent clearly defined social groups that used these vessels as rank or membership indicators (warrior bands,

professionals). It is certainly worthwhile enquiring whether this selective use of glass can be linked to other groups of material or the specifics of the burial rite in question.

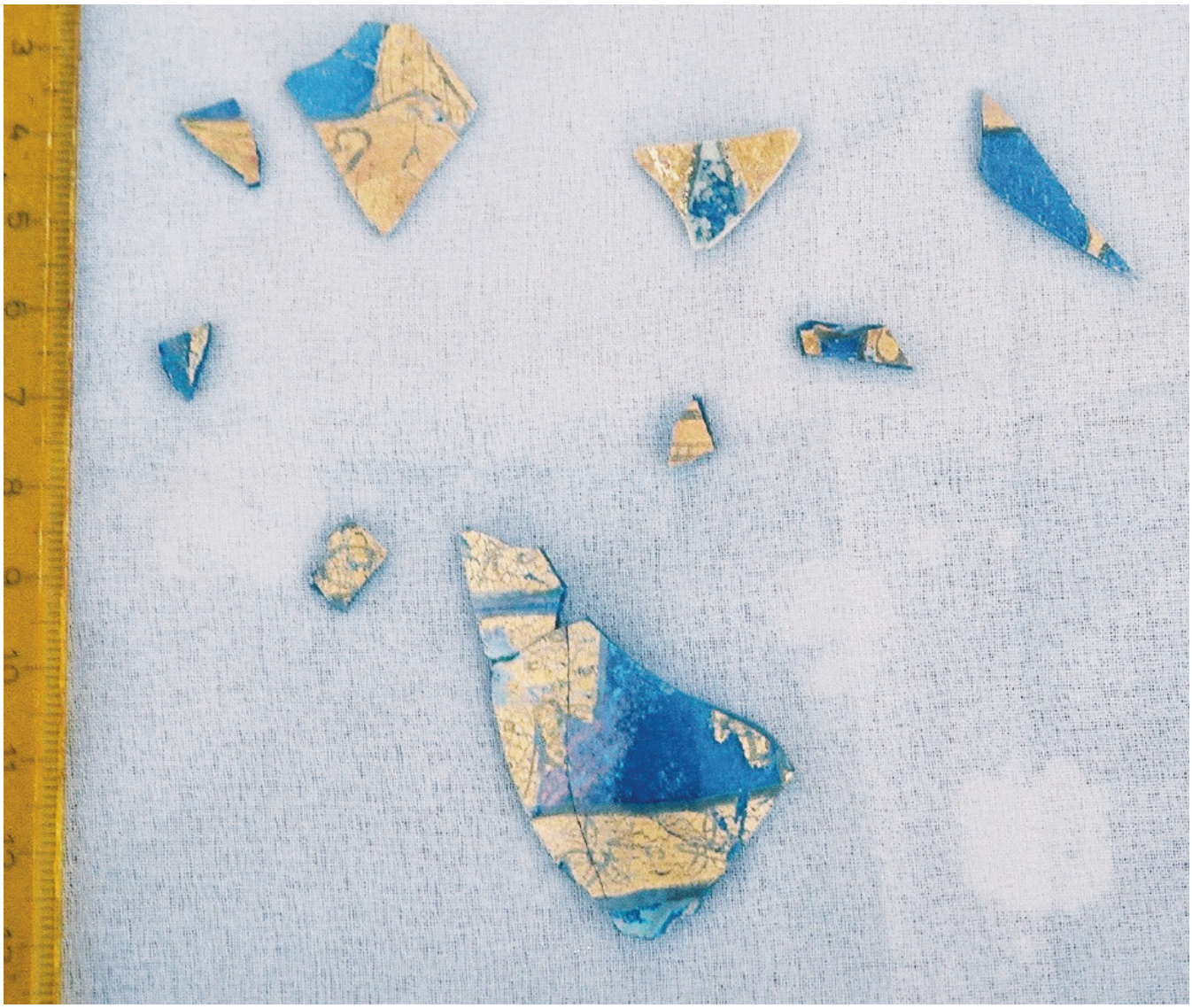

Fig. 9.3: Colourless glass vessel with fire-rounded rim and wheel-cut design (Germa Museum).

Overall the vessel glass found in the Fezzan suggests a continuous but changing use of glass over a period of at least 500 years, which shows the Garamantes to be an active agent in the selection and use of Roman material within their culture.

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10

SOME EXCEPTIONAL GLASS VESSELS FROM CAESAREA MARITIMA

Yael Israeli

The first anchorage at the site of Caesarea Maritima situated on the eastern coast of the Mediterranean, called Straton Tower, was established during the Hellenistic period. Herod the Great built there a large harbour and city and called it Caesarea. It was a prosperous city, built on a well designed grid plan and containing all the public institutions of a Roman city. The Romans transformed it into the administrative centre of the province and the seat of the Roman governor.

During the Byzantine period, the city expanded beyond the existing Roman plan and continued to be a provincial administrative centre. Churches replaced the pagan temples, but the city also contained a large Jewish and Samaritan population. During the Islamic period, Caesarea would lose its importance and be reduced to a tenth of the size of that of the Roman-Byzantine Period. During the 150 years of Crusader rule, it became a fortress, featuring a well developed system of walls whose remains may be seen to this day.

During the last century, many expeditions undertook investigations of various parts of the city, revealing numerous magnificent structures. In the 1990's, the University of Haifa conducted excavations south of the Crusader city walls, under the directorship of Prof. Joseph Patrich (Patrich 1999; 2008). The Byzantine governor's palace was exposed, as well as a large area of warehouses.

During the 7th century, following the Arab siege of the city and the ensuing conquest, the structures were deserted, and the area was levelled and converted into terraced gardens irrigated by wells and channels. The dismantling of the buildings prevented the preservation of the finds in their original contexts and so the objects recovered are mostly from refuse dumps and fills. Therefore, their dating relies mostly on stylistic well-dated parallels. The finds were processed during and immediately following Patrich's excavations, and have recently been examined anew. A detailed report of the glass finds is published as a separate chapter in an edited volume by J. Patrich (2008) *Archaeological Excavation at Caesarea Maritima*.

The assemblages from the governor's palace and the warehouse complex include thousands of glass fragments representing vessels characteristic of the Roman and Byzantine periods in Israel. The pieces are very fragmentary, as is usually the case in glass assemblages from settlements, in contrast to glass finds from tombs and burial caves.

In this short paper I shall describe eight pieces, albeit very small fragments, that are exceptional (illustrated in Fig. 10.1). They were mostly parts of imported vessels that had

never before been found in local excavations. Also included are two vessel types that are probably local products: the first is an oil lamp and the second's function is not certain, but it may have also been a lamp.

This paper was written in 2007, therefore more recent parallels found after this date are not included.

Sidonian mould–blown fragment (Fig. 10.1 (1))

A fragment of a small mould-blown vessel is one of the most intriguing among the vast body of glass finds from Caesarea. It was part of an open vessel, probably a bowl, decorated by mould-blowing. Remains of two strips of the mould-blown decoration can be seen on it, the upper exhibits a motif of flutes and arrows (called also gadroons and spikes), and of the lower one, separated from the upper by a horizontal ridge, only the edges of three leaves have been preserved. Luckily, even these scant remains allow for the attribution of the fragment to a rare group of mould-blown glass vessels, and for a reconstruction of its original shape.

A large group of mould-blown glass vessels of the 1st century AD is named after the city of Sidon on the Mediterranean coast of modern-day Lebanon. Greek inscriptions are integrated into the decorations, along with the names of their makers (Harden 1935, 164–170; Harden 1944–1945, 87–95). Altogether, names of five glass-makers are included in the decorations of the Sidonian vessels known to us. The most accomplished of these was Ennion. Dozens of beautiful vessels carrying his name are known, decorated with floral and geometric motifs enhanced by variegated colours. Most of the vessels carrying Ennion's name have no exact provenance; many come from Western sites but others from the eastern Mediterranean. Three have been found in Jerusalem (Israeli 1983).

Another artist who is close to Ennion in style is Aristeas. His name appears on a bowl from the Constable-Maxwell collection (Constable-Maxwell Coll. 1979, no. 280) and on two cylindrical cups with different decoration, one found near Pavia, Italy (Calvi 1965) and one in Narona, Croatia (Buljevic 2004, 188, no. 8). To date, these are the only vessels known to have been signed by Aristeas.

The fragment found in Caesarea apparently belongs to a vessel type similar to those of the two artists mentioned above. Its shape, of a bowl with rounded body and constricted mouth, is rare in the Sidonian group, but may be seen in two mould-blown vessels of Ennion (Harden 1935, 167; Harden 1944–1945, 89, pl. VIII), and one of 'Aristeas the Cypriote' from the Constable-Maxwell collection. Despite its small size, it seems likely that the fragment from Caesarea originates from a vessel similar to the Constable-Maxwell bowl, as the three leaves on it are identical to those on Aristeas' bowl. Still, it cannot be ascertained if both were blown in the same mould and if the fragment from Caesarea also carried Aristeas' name.

A seam between the mould parts can be noted, especially on the interior of the fragment, as well as at the point where the horizontal ridge above the leaves does not continue smoothly but terminates in two edges. A similar meeting point can be seen on the photograph of the Aristeas vessel in the sale catalogue of the Constable-Maxwell collection (Constable-Maxwell Coll. 1979, 159, lower left photograph).

Hemispherical bowl (?), body fragment. Mould-blown, a seam between parts of the mould can be discerned. Pale greenish-blue. Vertical rim (only lower edge), rounded shoulder. On shoulder flutes and arrows ('gadroons and spikes') motif, with horizontal ridge underneath. Below ridge edges of three leaves of a palmette(?).

3/96 NN14 0139 039 001 30 × 42mm.

Facet-cut bowl (Fig. 10.1 (2))

When cold, glass is hard like stone and can be cut with tools used for cutting and engraving stones. A blank or coarsely shaped vessel is created by casting or blowing hot glass and after the glass cools and becomes solid it is cut and shaped as if it were a precious stone. This was a difficult and complicated task for which expert artisans were required. One of the more common cut decorations in glass was facet-cutting, in which the vessel's face was cut in slanting planes.

Vessels decorated with facet-cutting have rarely been found in local assemblages. A large, impressive group of facet-cut vessels has been found in Dura Europus in Syria, dating to before the city's destruction in 256 AD. A bowl fragment covered in a facetted decoration has been found in Caesarea. Thus, the closest parallels to this piece are from Dura Europus (Clairmont 1963, 31, nos 241, 345), though no exact parallel is known to me.

Cylindrical bowl. Facet-cut. Colourless. Thinning rim cracked-off, vertical wall, flat base. On body two strips of elongated vertical facets in alternating order. Two horizontal grooves, one above facets and one near rim. On junction with base a circle of horizontal narrow facets, on flat base a circle of facets alternating with pairs of narrow facets arranged in inverted V design, with round facet between arms of V

10/94 CC14 0028 412 001 D: 95mm; H: 51mm.

Fish-shaped vases (Fig. 10.1 (3–4), 10.2)

Fish shaped vessels and fish motives were popular among decorated glass objects. Five groups of fish vessels have been classified by A. von Saldern (von Saldern 2004, 522). A large unique group has been found in Begram, Afghanistan with no exact parallels known from other provenances (Menninger 1996, 73–75, pls 24–25).

One fish bowl fragment from Caesarea belongs to Von Saldern's fifth group. It was made by blowing, and carries attachments of flattened glass strips and blobs. About ten nearly identical examples have been published, probably originating from the one workshop (Oliver 1980, No. 150; Kunina 1997, no. 201; Whitehouse 2001, nos 754–755; Fortuna Fine Arts Gallery cat. 2004, No. 35). Though from an unclear provenance, a few are said to have been found in Palestine, Lebanon and Syria. A fish vessel displayed in the Damascus Museum was found in Turbet el Acha'ari, Tafas in Syria (Zouhdi 1964, 45, fig. 27). On stylistic grounds, the Caesarea vessel type dates to the 3rd century AD.

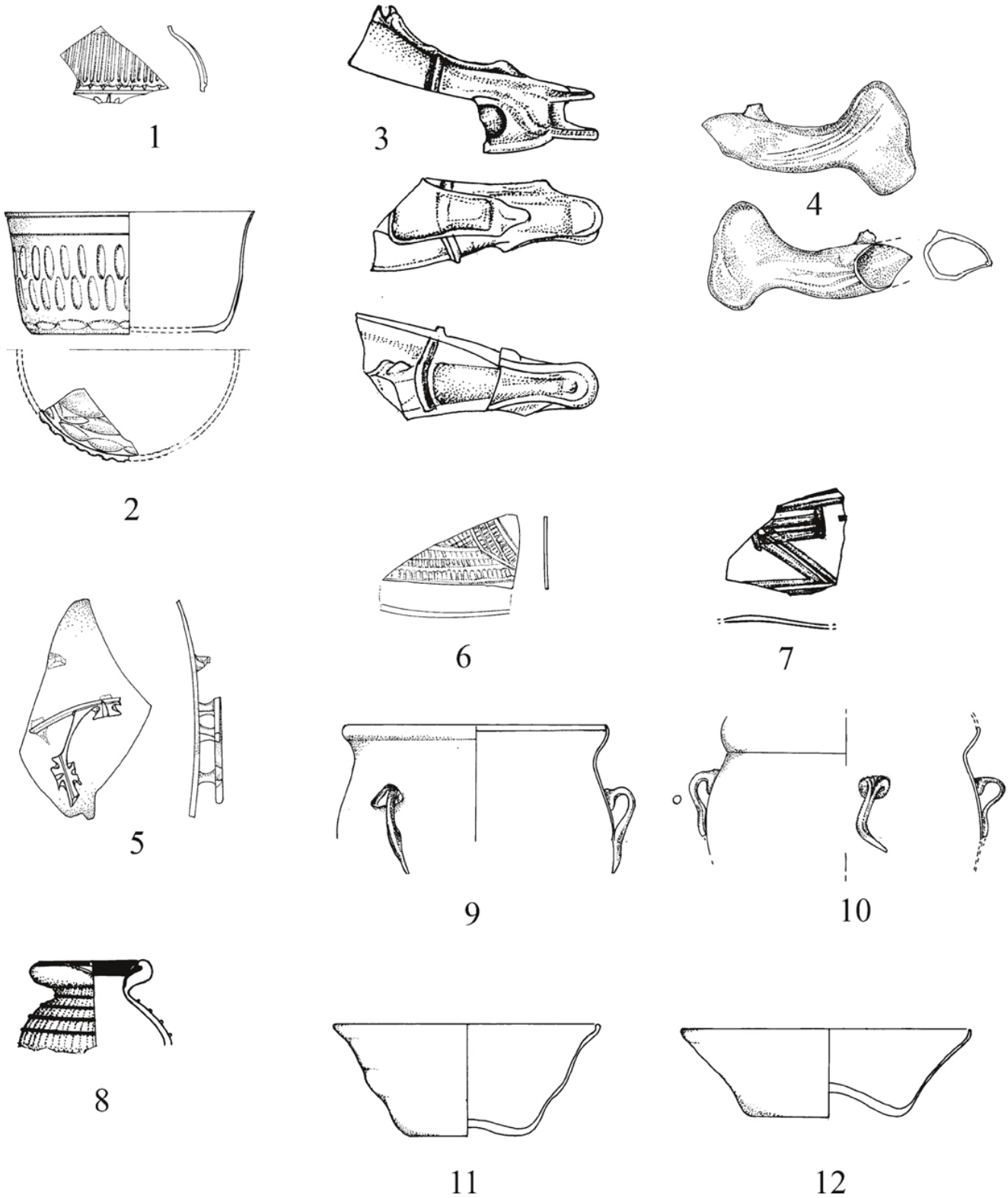

Fig. 10.1: Glass vessels from Caesarea Maritima mentioned in the text. Drawings by Nadia Levit and Sarah Halbreich.

Fig. 10.2: (3) Fish-shaped vessel.

A second example from Caesarea possibly depicts a dolphin, but too little of the vessel has been preserved in order to enable a reconstruction (von Saldern 1980, No. 113; Fortuna Fine Arts Gallery cat. 2004, no. 36). The closed tail and the translucent blue colour are reminiscent of the type L fish from Begram (Menninger 1996, 73–75, pls 24:1–2).

Fish flask. Blown. Colourless with pale yellow-green tinge. Open mouth, attached glass blob forming the eye, thin trail wound once as limit of head, flattened strip as top dorsal fin.
3/96 KK36 0128 L 085 001 L: 60mm.

Dolphin(?) tail fragment. Blown. Translucent blue. End of body with flattened large tail(?) attached blob of same glass, or possibly end of trail forming top dorsal fin.
7/95 KK20 0167 L246 001 L: 68mm.

A Cage Cup (Figs 10.1 (5), 10.3)
One of the most remarkable examples of glass art throughout history has been a group of vessels made of two glass layers, in which the upper layer is carved in various designs while the lower one serves as a background. These vessels are called *vasa diatreta* or 'cage cups'. The more common of these vessels has an outer layer carved as lace work or net, which envelops a body also made of glass (Subtype B in Harden and Toynbee 1959). In addition to the complicated method involved in producing such intricate beautiful vessels, they are created in various colour combinations, with the inner vase made of one colour and the outer

net composed of one or more colours. Some of the cage cups of Type B have a collar above the enveloping lace net and, at times, inscriptions in relief are found underneath the rim. Most of the inscriptions, in Latin or Greek, are toasts to drinking.

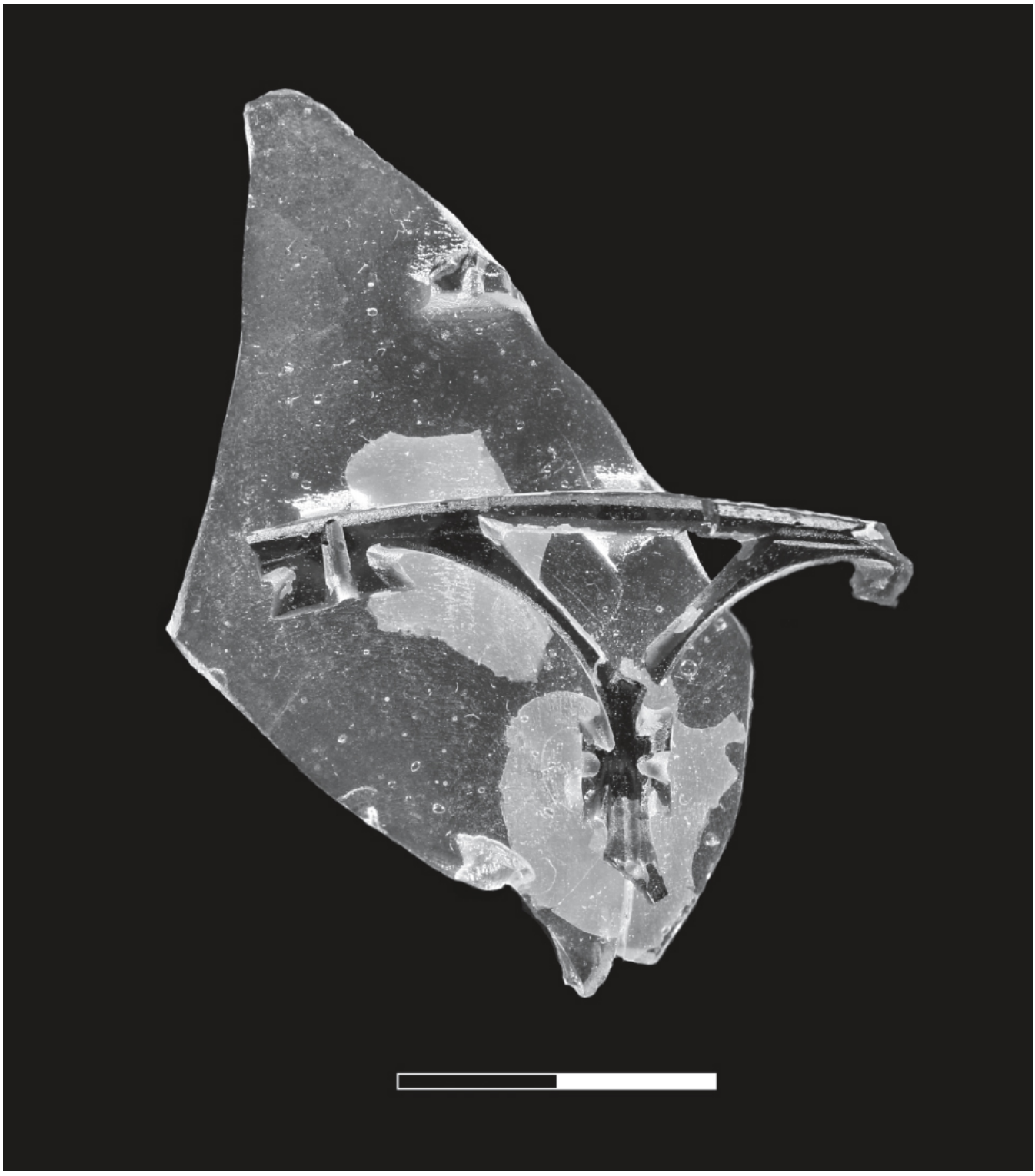

Fig. 10.3: (5) Cage cup fragment.

Among the glass fragments found in Caesarea is a piece that, although small, may be identified with certainty. Apparently it was part of a cylindrical or bell-shaped beaker, with a

network of glass around its body and possibly an inscription as well. The inner vessel and bridges connecting the net to the body were composed of colourless glass, while the outer net was made of blue glass. Very little of the vessel wall has been preserved and only a triangle between two meshes with two cruciform elements in blue and a tiny dot of blue glass situated on a bridge above the lace cage, which may have been part of an inscription, have survived. The vessel did not have a collar like some of the known examples, as indicated by the smooth part of the wall above the network. It seems to be an example of Type B-2 of the Doppelfeld division of the Harden and Toynbee Group B (Doppelfeld 1961, fig. 17:1, 3), though the number of rows of meshes and the height of the vessel cannot be ascertained from this tiny fragment. The combination of colourless glass and blue glass overlay appears also on a cage cup from Corinth (Harden 1963, no. 18; Weinberg 1964).

Cage cups are considered to date from the late 3rd and the 4th centuries AD. They were found in regions far removed from each other, such as Germany, Greece (Weinberg 1964), Bulgaria (Dimitrova 1974), Tunisia (Foy 2003, 70–71), and Aqaba in Jordan (Jones 2005, 138–139), and their place of production is unclear. The finds from Caesarea and Aqaba add an Eastern connection to this enigmatic group. More recent supplementary lists of cage cups and a bibliography on the subject have been published by von Saldern (von Saldern 2004, 398–399; the piece from Caesarea is mentioned there as unpublished).

Beaker, wall fragment. Cast or blown and cut. Colourless with very slight greenish tinge. A blue network is attached to the wall. Preserved are: section of upper ridge, connected to wall by two bridges with one cruciform element and tip of another, upper sections of two meshes (quarter circles), a longer cruciform element between them with a bridge underneath, connecting the two circles. The bridges are of colourless glass. Above the ridge a thicker bridge of colourless glass with tiny remains of blue glass on top of it, possibly the remains of a letter.

7/95 KK24 0139 036 001 H: 60mm; W: 37mm; Th: 1.5mm; H of bridges 3–5mm.

Fragments with wheel-incised decoration (Fig. 10.1 (6–7))

Two fragments of engraved bowls or dishes found at Caesarea appear to be examples of rare Byzantine glass art. The first is too small to enable reconstruction of its original shape, but seems to have belonged to a group of vessels covered on the outside in engraved geometric designs of frames filled with crosshatching, ladders and parallel lines. A similar small bowl fragment with geometric designs and a star was found at Jalame, in north Israel (Weinberg and Goldstein 1988, 101–102, no. 517, figs 453). Few examples have been published that appear to belong to the same group, and most originated from the West (Kisa 1908, 634–636, figs 238, 240; Whitehouse 1997, no. 446).

The second fragment features the letter Z incised in double lines. The letter may be part of the inscription – *pie zeces* – ('drink live'), which is quite often found on glass beakers and drinking bowls from the Roman and Byzantine periods. A large group of vessels depicting inscriptions with letters incised in double lines was published by Harden (Harden 1967/8; Grose 1985). He dates the vessels to the 4th century AD and divides them into two groups: one of goblets from Egypt and the other of flasks and bowls from Asia Minor. Two of the vessels in Harden's list do not belong to either of these groups and apparently form a third group. Both exhibit a single tiny 'double S-formed handle' and a toasting inscription in Greek. One was unearthed in excavations in Cologne and the other 'is said to have been found near Jerusalem' (Harden 1967/8, 50–51, 53–54, pl. 10:5, 6; Ross 1962, no. 94). Harden discusses

the possibility of the Cologne bowl having been imported from the Syria-Palestine region, but as it is of better craftsmanship than the 'Jerusalem' one, he considers the likelihood that the trend of engraved doublelined letters originated in Egypt, was then brought to Syria-Palestine, and from there to the Cologne region, possibly by an itinerant glass-maker. A beaker inscribed with double-lined letters from Petra has recently been published, dating to the mid-4th century AD (Keller 2006, 211–12, pl. 12). In view of the finds from Ain et-Turba near the Kharga Oasis in Egypt (Hill and Nenna 2003, 90, fig. 4:1, 2), Keller suggests an Egyptian origin for the third group of vessels with doublelined letters (Keller 2006, 118).

Shallow bowl or dish, body fragment. Colourless. Elaborate engraved decoration of three parallel ladders forming a V shape; a criss-cross pattern between the arms of the V. The long lines are slightly curved and not exactly parallel.

10/94 CC 30 0011 004 001L: 59mm; W: 28mm.

Flat body fragment, probably of a dish. Colourless with slight greenish tinge. Wheel abraded decoration, the letter Z superficially engraved in double lines with two parallel lines above it.

7/95 CC18 0293 L. 953 001 L: 43mm; W: 25mm; H of letter: 20mm.

Small jar decorated with blue trails (Fig. 10.1 (8), 10.4)

This style of decoration is found in sites in Israel and is typical of the late Byzantine period. It was also common in Beirut, and probably produced in several workshops in the large centres of the region in the 6th and 7th centuries AD (Foy 2000, 259, 263–268, figs 16, 18–19; Jennings 2006, 155–165). A small jar of this group found among the Caesarea material seems to be a rare example for which no parallel is known to me.

Fig. 10.4: (8) Jar with blue trail.

Small jar. Colourless. Thickened, everted rim, rounded shoulder, ribbed body blown in dip mould. On rim, a thick dark blue trail dragged into a thread wound four times on shoulder.

10/94 KK28 0225 105 001 Rim D: 30mm H: 22mm.

Oil lamps (Fig. 10.1 (9–10))

The largest group of glass vessels from the governor's palace and the warehouse complex is oil lamps. This functional vessel is represented by numerous shapes and types dating from the 4th century AD throughout the Byzantine period. They include various bowls, cup-shaped lamps, conical beakers, and suspension lamps with stems. An intriguing question is whether they had been in use in the public buildings exposed in Patrich's excavations or collected from elsewhere and dumped as part of a fill. Hundreds of oil lamp stems were found in a salvage excavation along the southern stretch of Caesarea's Byzantine wall (Peleg and Reich 1992, 155–156, fig. 18:17, 20). The excavators propose that the oil lamp stems were waste from a neighbouring glass factory.

A local oil lamp type seems to be the deep bowl with a cracked-off rim and three handles for hanging, of which several pieces were found. One similar example was found in the above-mentioned salvage excavation (Peleg and Reich 1992, 155, fig. 18:19). An oil lamp of similar shape but with different handles was published from the Mount of Olives in Jerusalem (Barag 1970, 183–184, Type XIII:10). Two small handles from Beirut are very similar to the crooked handles of these lamps from Caesarea (Jennings 2006, 151–152, figs 6.24: 89, 6.26).

Deep bowl. Pale greenish-blue. Cracked-off rim. One handle (suspension loop) preserved, formed from blob attached to upper part and dragged diagonally down; originally there were probably three handles.

10/94 CC13 0197 320 001 Rim D: 90mm; H: 43mm.

Deep bowl, in fragments. Pale greenish-blue. Swollen rim, cracked-off and irregular. Three blobs attached to upper part from which strips are dragged diagonally down, and attached to wall, forming three 'handles' (suspension loops).

10/94 CC51 0122 075 001 Rim D: 95mm; H 53mm.

Small bowls (Fig. 10.1 (11–12))

A large number of carelessly made small bowls, of unknown type, was found at Caesarea. All had rounded rims and thick walls tapering to a thicker, slightly concave bottom. Their colours vary, most are light green or blue, and all display a pontil mark.

The large number of the bowls is intriguing, over one hundred such vessels have been found, and all in a single area of the excavation. Their exact date and function are unclear, but they may have served as small lamps, and were definitely produced locally.

Small bowl. Pale blueish. Slightly thickened inverted rim, sloping wall, thickened concave base with pontil mark.

10/94 CC18 0265 940 007 Rim D: 100mm; H: 42mm

Small bowl. Pale bluish-green. Rounded thickened rim, sloping wall, thickened concave base with pontil mark.

10/94 CC04 0100 012 101 Rim D: 110mm; H: 33mm

Apart from the latter two types (Nos. 9–12), it appears that the vessels discussed in this paper were imported to Caesarea, most probably from neighbouring regions in the eastern Mediterranean littoral. The origin of the cage cup fragment remains a mystery in spite of the relatively large number of known pieces. Additional finds and future excavations will likely provide answers to these questions.

Acknowledgements

I am delighted to contribute this short paper in honour of Jennifer Price. Jenny's work has always been for me a model of accuracy and clarity, her approach careful and resolute at the same time. It was Jenny who encouraged me to work on the glass assemblage from the excavation of the Governor's Palace and Warehouse Complex of Caesarea. I would also like to thank Prof. Joseph Patrich for allowing me to publish these items.

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11

GLASS IN THE DOMESTIC SPACE: CONTEXTUAL ANALYSIS OF LATE ROMAN GLASS ASSEMBLAGES FROM EPHESUS AND PETRA

Daniel Keller

Introduction

Contextual analysis and interpretation of glass finds in order to establish household activities are uncommon in glass research. This paper aims to demonstrate that such studies, examining Roman glass *within* the archaeological context, are not only possible but also rewarding. This paper has been written to thank Jennifer Price for all the help and encouragement she has given me over the years: initially whilst I was working on my doctoral thesis and subsequently during several glass projects.

The ideal circumstances for a contextual analysis of household activities and the role of glass vessels are *in situ*-contexts or sealed deposits caused by earthquakes, volcanic eruptions or fires without any later disturbance after the catastrophic event. Furthermore, recognisable glass vessels, or fragments of them, and careful excavation and recording of the contexts are necessary. Pompeii, Italy, in AD 79, first comes to mind when considering glass from Roman deposits. Unfortunately, this avenue of research was not followed extensively in the past and little of the glass recovered from Pompeii has been published. L. A. Scatozza Höricht (1990) has briefly presented an overview of glass vessels from several houses in Pompeii, and published one set of glass vessels from the atrium of House I.8.5. Joanne Berry (1997) has studied the finds and household activities in House I.8.14 and Penelope M. Allison (2004 and 2006) has recently analysed the household activities of several Pompeian houses in general and presented a detailed contextual analysis of the *insula* of the Menander. However, Berry's and Allison's studies were based on the excavation records and not on the actual finds and, in those cases where the glass vessels are presented in more detail, such as the finds from the *insula* of the Menander, their significance is not fully realised. In contrast, a fascinating insight into research which assimilates excavation records, glass finds and recent on-site analysis of glass in House I.8.5 at Pompeii was presented by Souen Deva Fontaine at the 17th Congress of the *Association Internationale pour l'Histoire du Verre* in Antwerp in September 2006 (Fontaine 2009). The full publication of this work is widely anticipated.

Despite this paucity of published syntheses, some preliminary remarks on the storage of glass tableware in Pompeian households can be made. In House I.8.14, glass vessels were obviously used as tableware and glass tableware was mainly kept in the atrium (room 2) or in

the small room (room 8) close to the kitchen (room 11) and the open dining area 7 (Berry 1997, 188–192, fig. 4). From both rooms 2 and 8, where glass tableware was found, the dining rooms 6, 7 and 9 could be easily reached. Hence, glass tableware was evidently kept in rooms located in the vicinity of the dining rooms. This picture is confirmed by the analysis of the data provided in the online database of Penelope Allison for several other Pompeian houses (http://www.stoa.org/projects/ph/home). Five houses analysed in her study have glass assemblages in the atrium, two more houses have glass vessels kept in small rooms close to the atrium (Allison 2004, compare also Allison 2006, 389). The fact that glass tableware was often kept in the atrium of the Pompeian house was noted by Scatozza Höricht (1990, 46), where eight examples are listed – one of them being from the house later studied by Berry (1997) and another from the house recently presented by Fontaine (2009) – and eight more houses are mentioned with glass vessels in small rooms close to the atrium. Therefore, it can be concluded that in Pompeian houses, glass tableware might have been kept in the atrium or small rooms close to the atrium.

Furthermore, glass tableware was often not kept exclusively in these rooms but was stored together with pottery and bronze tableware as is demonstrated by finds from the *Casa della Venere in Bikini*, the *Casa del Fabbro*, the *Casa del Sacello Iliaco* and the *Casa del Menandro* (http://www.stoa.org/projects/ph/home; for the houses in the *insula* of the Menander compare also Allison 2006, 389) as well as from the house I.8.5 (Fontaine 2009, 117–119). Allison (2004, 134) explained the keeping of tableware as 'the need to maintain its visibility so that it could be accounted for'. However, with the cupboards containing glass tableware in the house of Julius Polybius (Allison 2004, 52, fig. 4.10) or the chest with glass vessels from the *Casa del Menandro* (Allison 2004, fig. 6.1; Allison 2006, pls 14.2 and 14.4) for example, their visibility is not really in evidence. However, the fact that the glass vessels were kept in an ideal place on the way to the dining rooms remains a common feature.

As a comparison, this paper will focus on two sites where domestic buildings were destroyed by earthquakes in the Late Roman period; Ephesus in Turkey and Petra in Jordan. In both cases the glass vessels and their related contexts are well recorded and published. The first example is housing unit 4 of terrace house 2 in Ephesus, Turkey, which was destroyed by an earthquake in the 3rd quarter of the 3rd century AD (Thür *et al*. 2005), the second are the houses on the terraces ez Zantur IV and ez Zantur I in Petra, Jordan, which were destroyed by earthquakes in AD 363 and the 1st half of the 5th century AD respectively (Keller 2006). Compared to the glass finds from Pompeii there is a remarkable difference; the excavations in Pompeii often revealed complete glass vessels (Scatozza Höricht 1990, fig. 1; Allison 2004, fig. 6.1; Allison 2006, 442–444, appendix B.B, figs 9–14; Fontaine 2009, fig. 2), whereas the glass vessels from the earthquake deposits at Ephesus and Petra are only preserved in a fragmentary state (Thür *et al*. 2005, pls 233–234; Keller 2006, figs 18–29, 63–67, 74–77). This is due to the dissimilar types of destruction at each site and thus the different formation of the relevant deposits. In Pompeii the houses were filled with *lapilli* from the eruption of Vesuvius (Berry 1997, 188) which acted as a partial protection for the artefacts when parts of the roof and walls collapsed. Moreover, the glass vessels were often kept in cupboards and chests, which protected the vessels from further damage, even from the *lapilli*. In contrast, the glass vessels in Ephesus and Petra seem to have been kept on wooden shelves (Thür *et al*. 2005, 47, 247, 370, pl. 30.1; Keller 1996, 301 note 935; Keller 2006, 149, 161) and were directly hit by the collapsing roofs and walls. This resulted in a large quantity of very small fragments which were not all recognised or recovered during the excavation or were incomplete fragments which could not be reconstructed into complete vessels during post-excavation analysis.

Ephesus: terrace house 2, housing unit 4

The Austrian Ephesus team has published a comprehensive volume on a housing unit of terrace house 2, presenting it as a contextual analysis in an exemplary piece of research (Thür *et al*. 2005). Housing unit 4 of terrace house 2 was destroyed by an earthquake in the 3rd quarter of the 3rd century AD (Thür *et al*. 2005, 242, 430). The resulting numbers of glass vessels were calculated from the list by Thür *et al*. (2005, 370–372) and the catalogue of the relevant finds published by Thür *et al*. (2005, 372–388) using the method of establishing an estimated minimum number of vessels in an assemblage (EMN) as defined by Cool and Price (1995, 9–10). The largest number of heavily fragmented glass vessels comes from room 14 (Fig. 11.1), where two rather large assemblages were found. The first consisted of three deep bowls, five cups and five closed vessels (Thür *et al*. 2005, 372, pl. 233.1), the second included one shallow bowl, three deep bowls, three cups and two closed vessels (Thür *et al*. 2005, 370–371, pl. 233.2). Further glass assemblages were found in room 14cG, with one shallow bowl, one deep bowl, three cups and one closed vessel (Thür *et al*. 2005, 371, pl. 234.1), in room 14d with four deep bowls and two cups (Thür *et al*. 2005, 371) and in room 19 with three closed vessels (Thür *et al*. 2005, 371). In addition to the glass tableware, pottery tableware, mainly consisting of plates and bowls, was found together with ceramic cooking ware in all four rooms; room 14 also contained pottery amphorae (Thür *et al*. 2005, 247–256, 259, figs 43–44). This suggests that glass tableware was stored in these rooms together with pottery tableware, and also with utilitarian or cooking ware.

Analysing the spatial distribution of glass vessels (Fig. 11.1) in association with the architectural layout of the ground floor of housing unit 4 and the room functions, the following conclusions regarding the storage and use of glass vessels in this mid 3rd-century AD household in Ephesus can be suggested. Room 14 is most likely the kitchen of housing unit 4 (Thür *et al*. 2005, 419) where not only two large sets of glass tableware were kept but also pottery tableware as well as common or cooking ware and amphorae, thus providing evidence for the storage of large pottery and glass assemblages in the kitchen of a domestic dwelling dated to the mid 3rd century AD. Furthermore, the glass and pottery tableware kept in room 14 were ideally placed to be brought in together with the food from the kitchen to the dining and reception rooms of the ground floor located in rooms 7 and 15 (Fig. 11.1; Thür *et al*. 2005, 416–417, pl. 245). A parallel for this practice was found in a house in Petra on the terrace ez Zantur III, which was abandoned in the mid 3rd century AD. Here a similarly large set of glass tableware was found in the kitchen, together with ceramic table- and cooking ware (Keller 2006, 141–142, tables 49–50).

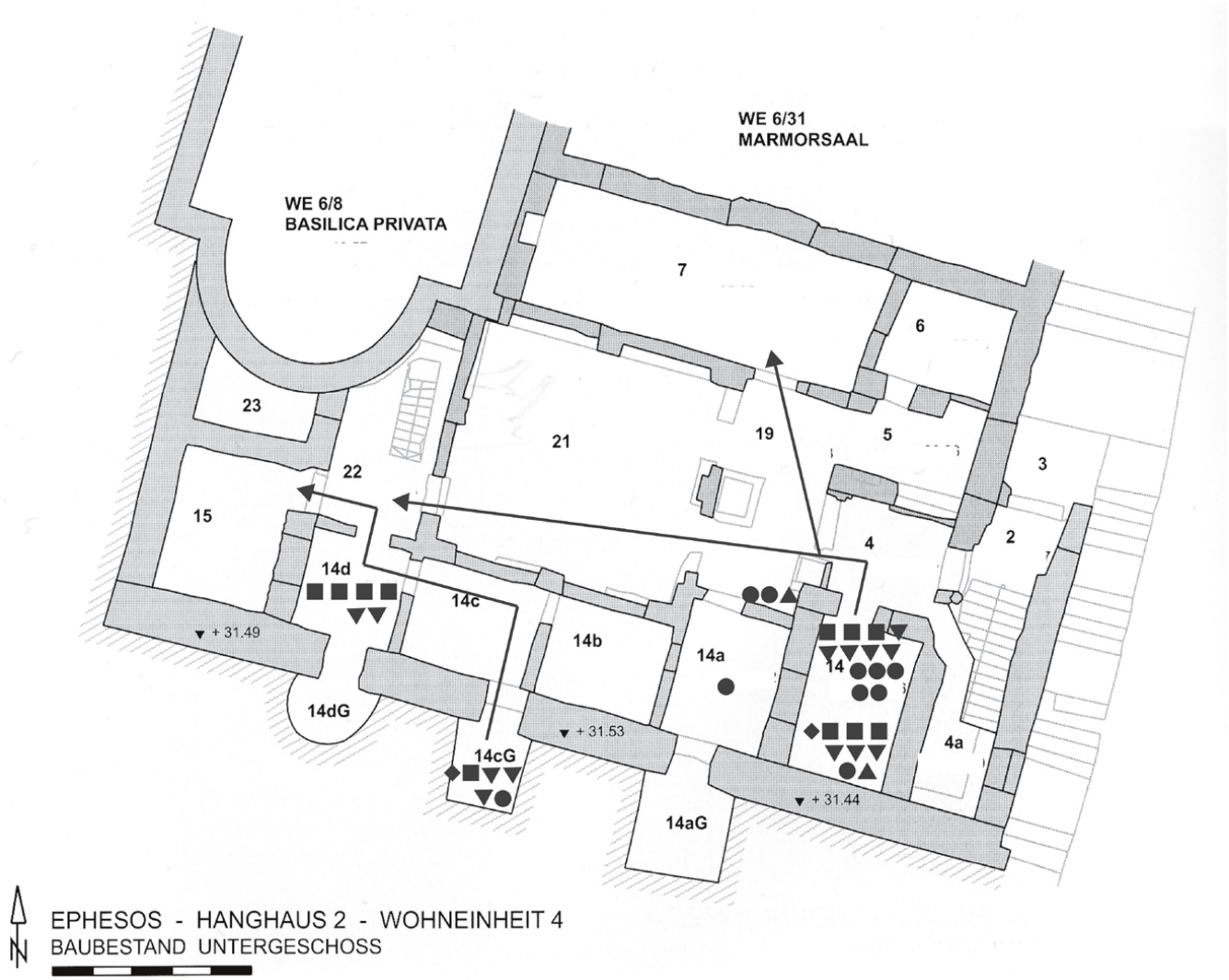

Fig. 11.1: Ephesus, terrace house 2, housing unit 4 with the spatial distribution of glass vessels and the way from the storage rooms to the dining rooms (D. Keller after Thür 2002, fig. 21 and the table of finds and contexts by Thür et al. 2005, 370–372). (Key: ♦ shallow bowl; ■ deep bowl; ▼ cup; • jug; ▲ flask).

The architectural layout of the ground floor is an important consideration when reconstructing the function of particular rooms and the interpretation of the use and storage of the glassware found in these spaces. This is particularly important when discussing the glass tableware from rooms 14d and 14cG. The vaulted room 14cG opens only into room 14c in front of it. From 14c the only thoroughfare is into room 14d; the adjacent entrance leads into 14b which is a dead end. 14d leads then into room 22 which is the anteroom of the dining/reception room 15. Therefore, it is likely that the glass tableware stored in rooms 14d and 14cG was intended chiefly to be used in the dining/reception room 15 where it could have been brought easily (Fig. 11.1). Furthermore, the brick platform in room 14d may well indicate that food was heated, kept warm or re-heated there for consumption in room 15 (Thür *et al.* 2005, 418). This would suggest that glass tableware was not only kept in the kitchen but also in rooms where other tableware was generally kept and which were close to or nearby the dining/reception room. A parallel for the latter is attested by the glass assemblage from a small room adjacent to the main reception room of the so-called *domus* of terrace house 1 at Ephesus, which was destroyed by the same earthquake in the 3rd quarter of the 3rd century AD (Czurda-Ruth 2007, 221, 228, no. 16, pls 31.16 and 32.16).

Petra: ez Zantur IV

Between 1996 and 2001 the Swiss-Liechtenstein excavations at Petra uncovered a large Nabataean domestic building on the terrace ez Zantur IV in the south of the ancient city of Petra, which was built in the early/mid 1st century AD, but remained in use until its sudden destruction in the earthquake of AD 363 (Kolb 2001, 438–439; for the earthquake and the historical records relating to it see Russell 1980, 47–64; Russell 1985, 42; Amiran *et al*. 1994, 165; Guidoboni 1994, 264–267). The glass vessels used in this house at the moment of destruction in the earthquake were sealed by the collapsing roofs and walls, as well as by the collapsed stucco decoration from the walls and ceilings. Although there is some evidence for later disturbance through the removal of artefacts, these affected only reusable metal ware (Dozio 2005, 20) and building stones from walls. The glass and pottery were left behind and remained largely untouched and undisturbed (Keller 2006, 143 note 820). Therefore, the glass finds from the earthquake contexts within the house on the terrace ez Zantur IV can be considered to belong to *in situ*-contexts (Fig. 11.2).

The analysis of the glass finds from these *in situ*-contexts (Fig. 11.3) provides evidence for the different sets of glass vessels used in this Late Roman household (Keller 2006, 143–147, tables 51, 68, figs 62–68; the numbers are estimated minimum numbers of vessels in an assemblage according to Cool and Price 1995, 9–10). Distinctive glass vessel types used in the kitchens (rooms 31 and 37) include large bottles and small jars (Keller 2006, 147, 152–153, service 4a, table 51, figs 67–68; Keller 2012, 107–108, figs 5–6), while glass tableware sets consisting usually of three beakers, a shallow bowl and a jug or flask occasionally supplemented by a second jug or flask and two dropper flasks, were found in the dining and reception rooms of the house as examples from rooms 6, 14 and 27 demonstrate (Keller 2006, 143–145, 147, 150–152, services 1a–1b, 2a, table 51, figs 63, 65, 68). Larger sets of glass tableware consisting of up to two large deep bowls, two small deep bowls, three or four beakers/cups and two jugs or flasks as well as two ceramic plates of African Red Slip ware were also found in this house, but they came from the small rooms 11, 12, 16, 36.1 and 36.2 which were clearly used to store glass and pottery tableware (Keller 2006, 145, 147–149, services 3a–3b, table 51, figs 66, 68). In these rooms (except room 16) as well as in the small rooms 3 and 13, drinking vessel sets, similar to those from the reception rooms, were found (Keller 2006, 145, services 1a–c, table 51, figs 62, 68).

A stylistic difference can be noted between the glass from the dining/reception rooms and the glass from the kitchens and small storage rooms. The three beakers and the bowl of the glass sets 1a–c from the dining rooms are usually made of a better quality colourless thick-walled glass, often decorated with wheel-cut lines, whereas the glass from the other rooms is mainly a common green-blue glass typical of the Late Roman and Byzantine period in Petra (Keller 2006, 143–147). Of course, some of the better quality beakers were also found in the rooms in which tableware was kept, but the common tableware glass predominates (Fig. 11.2). This indicates that sets of good quality drinking vessels were kept in the dining and reception rooms of the house on ez Zantur IV at the time of its destruction by the earthquake in AD 363, whereas additional, mainly common glass tableware was stored in smaller rooms and kitchens.

Another conclusion which can be drawn from the spatial distribution of the glass vessels in the house on ez Zantur IV, is the connection between the storage of the larger sets of glass tableware and the architectural layout of the house (Fig. 11.3). The large tableware sets 3a–c were kept together with other good quality drinking vessels (sets 1a–c) either in the small rooms 36.1 and 36.2 next to the two kitchens (rooms 31 and 37) or in small rooms or parts of rooms (rooms 3, 11, 12, 13) next to the dining/reception rooms 6, 14, and 27 (Keller 2006,

152, fig. 69). Therefore, they are ideally placed either en-route from the kitchens to the dining rooms, or in the close vicinity of the dining rooms, and so were easily accessible when needed. This is a similar way of keeping glass tableware to that demonstrated above in specific houses at Ephesus and Pompeii.

Fig. 11.2: Petra, ez Zantur IV with the spatial distribution of glass vessels (D. Keller). (Key: ◄ plate; ♦ shallow bowl; ■ large deep bowl; ■ small deep bowl; ▼ cup; ▼ beaker; • jug; • bottle; ▲ flask; ▲ jar. Red – better quality colourless glass; blue – common green-blue glass; green – better quality pale green glass; yellow – imported yellow glass).

Petra: ez Zantur I

The two small Late Roman houses on the terrace ez Zantur I in the southern part of Petra, to the northeast of ez Zantur IV, were excavated by the Swiss-Liechtenstein team between 1988 and 1994. Built in the early 4th century AD, they overlie the remains of a Nabataean house. Similar to the large house on ez Zantur IV, they were also destroyed by the earthquake of AD 363, but in contrast to the large house, they were rebuilt in the late 4th century AD and were finally destroyed in another earthquake during the 1st half of the 5th century AD; the site was abandoned thereafter (Kolb 2000, 238, 243–244, 248–249). In their last phase, the two houses belonged most likely to one housing unit (Kolb 2000, 249; Keller 2006, 179). Similar to the remains in the ez Zantur IV structure, the collapsing walls sealed the pottery and glass vessels used at the time of the earthquake and the assemblages were not disturbed later, thus providing *in* situ-contexts (Fig. 11.4).

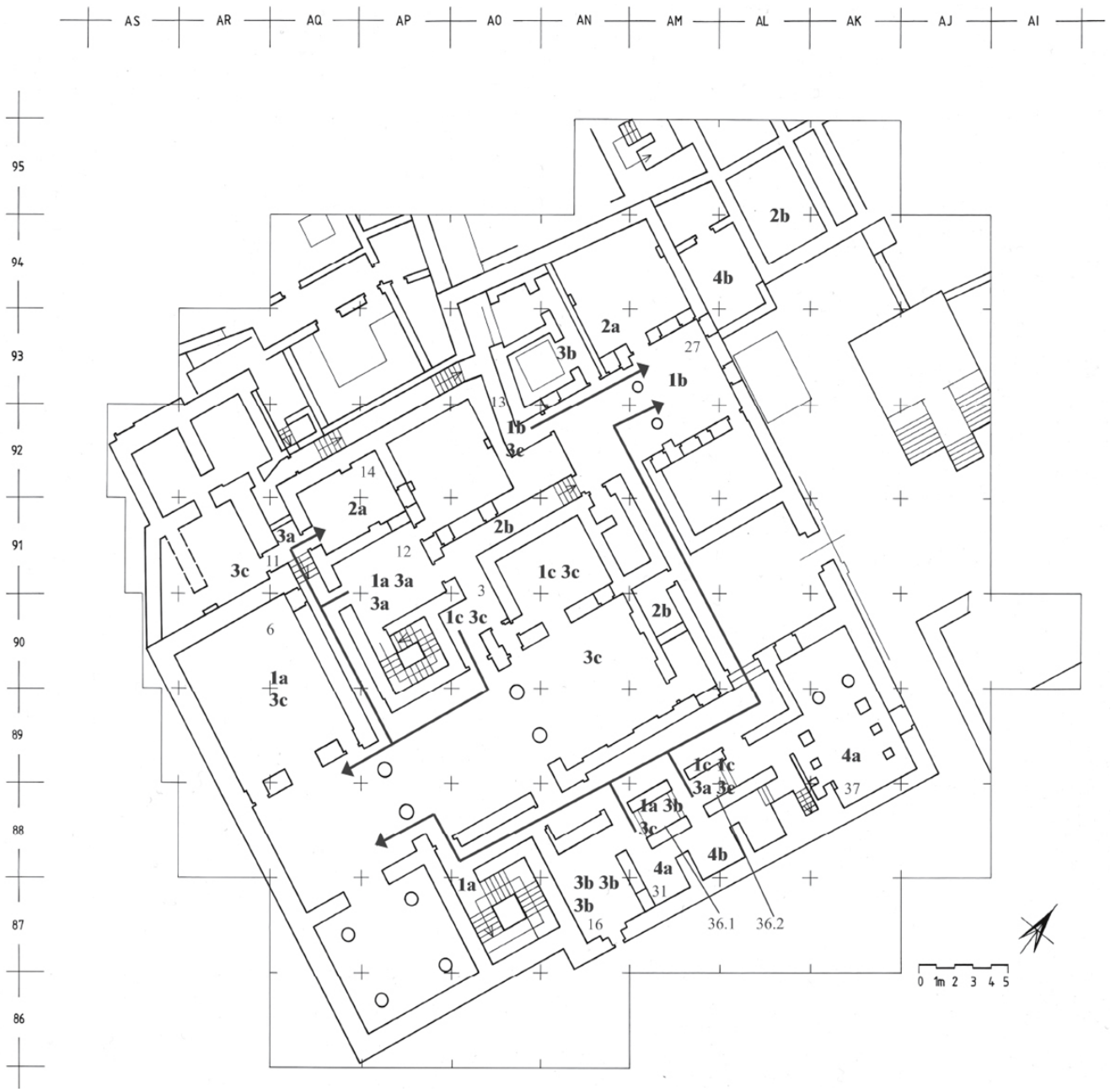

Fig. 11.3: Petra, ez Zantur IV with the glass sets used or displayed in dining rooms, kitchens and the storage rooms of large glass tableware sets and the way from the storage rooms to the dining rooms (D. Keller).

The analysis of the glass finds from these contexts (Fig. 11.5) led to the recognition of different sets used in the house at the time of its destruction (Keller 2006, 156–161, tables 53, 70, figs 72–77; again, the numbers are estimated minimum numbers of vessels in an assemblage according to Cool and Price 1995, 9–10). Similar to the previous example, this house also yielded a distinctive set of glass vessels used in the kitchen/courtyard (room 8). This consisted of several flasks, jugs and small jars (Keller 2006, 160–161, service 4a, table 53, figs 73, 76). In the living rooms of the house (rooms 9, 27 and 28) as well as in parts of the kitchen/courtyard (room 8), sets of glass tableware consisting of three to five deep bowls, one or two cups and two to four flasks or jugs were found (Keller 2006, 161, service 3d, table 53, figs 73, 77), whereas in the largest room of the house (room 2) and in the entrance room 4, glass tableware sets with four beakers/cups and a small flask and three beakers/cups, one bowl and two flasks or jugs were recorded (Keller 2006, 157, services 1c, 2a, table 53, figs 73–75).

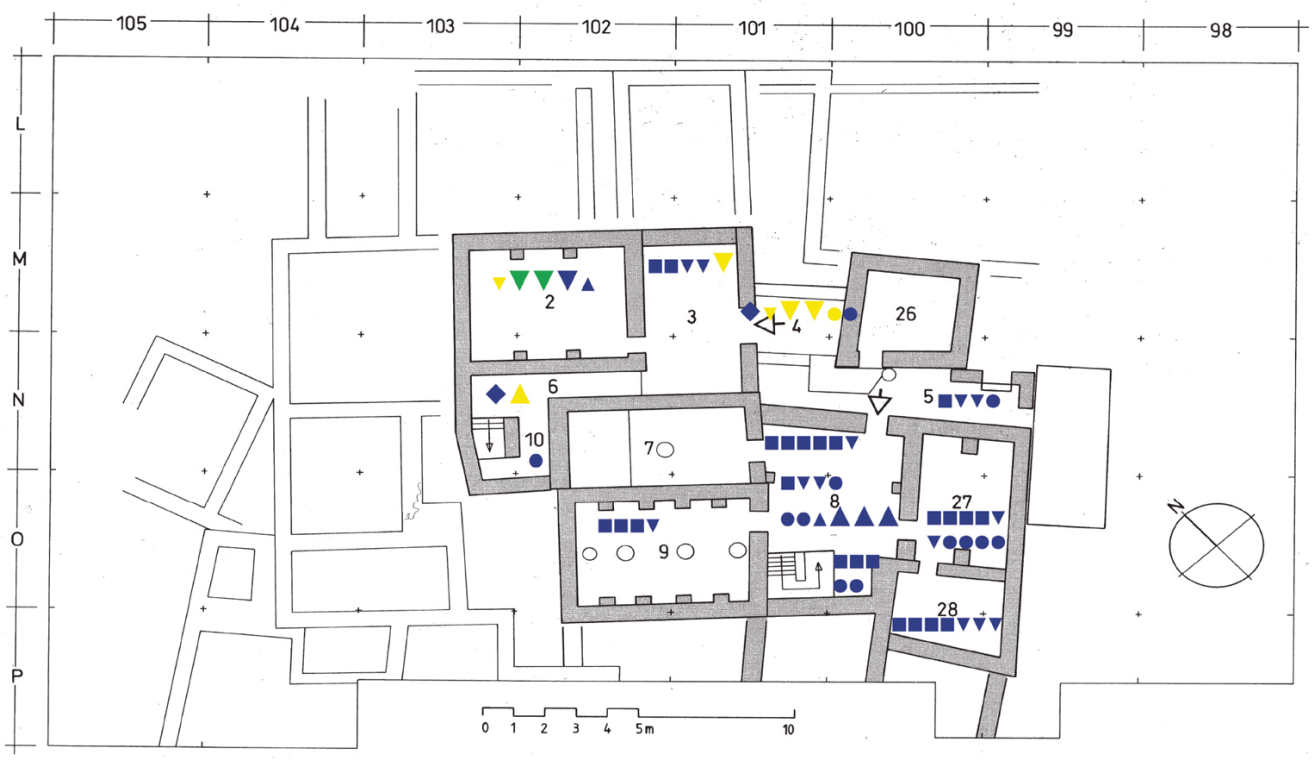

Fig. 11.4: Petra, ez Zantur I with the spatial distribution of glass vessels (D. Keller). (Key: ♦ shallow bowl; ■ small deep bowl; ▼ cup; ▼ beaker; • jug; ▲ flask; ▲ jar. Blue – common green-blue glass; green – better quality pale green glass; yellow – imported yellow glass).

The preference for glass bowls in this Late Roman house is remarkable, as glass beakers and cups are the predominant vessel form in Petra in the 4th/5th century AD (Keller 2006, 127–132, 137–140, 179). Nevertheless, glass bowls are found in higher numbers than beakers in this house. If the size of the small house on ez Zantur I is compared to that of the large house on ez Zantur IV, destroyed a few decades earlier, the preference for glass bowls in the smaller house can be explained by a difference in the social status of the inhabitants at each house. The apparently higher status inhabitants of the large house on ez Zantur IV used glass beakers as their drinking vessels as these beakers correspond with the Late Roman way of

drinking (Keller 2006, 176–178). The inhabitants of the small house on ez Zantur I presumably belonged to a lower social standing and they preferred glass bowls because of their multi-functional use both as drinking and serving vessels (Keller 2006, 161, 179–180).

In the Late Roman house on ez Zantur I a difference can be noted between the glass used or stored in the courtyard, which served as a kitchen (room 8), and the living rooms surrounding it (rooms 9, 27 and 28), and the glass used and stored in the entrance room 4 and the large dining room 2 in the vicinity of the entrance (Figs 11.4–11.5). In the kitchen and living rooms, bowls predominate (sets 3d), but in the large dining room and in the entrance room, two glassware sets each with three or four beakers/cups are present (sets 1c and 2a), similar to those used in the earlier Late Roman house on ez Zantur IV. Although the good quality colourless thick-walled glass from the 4th century AD is absent in these early 5th-century AD contexts, there is still a difference in quality between the beaker/cup sets 1c and 2a in the dining and entrance rooms and the bowl sets 3d in the kitchen and living rooms (Figs 11.4–11.5). The glass vessels from the latter rooms are all made of ordinary blue-green glass, whereas the beakers and cups from the entrance room 4 are all made of a distinctive and, for Petra, rare yellow fabric. Similarly, the beakers and cups from dining room 2 predominantly belong to the same yellow fabric or are made of an equally rare pale-green glass. Both glass colours occur in Petra only for a short period in the late 4th and early 5th century AD in small numbers and may therefore be regarded as potential imports (Keller 2006, 117–119). This indicates that the beakers and cups were certainly more valuable than the ordinary bowls, thus providing evidence for a difference in quality between the better glass used and kept in the dining room and the entrance room in the front part of the house, and the ordinary glass used and kept in the living rooms and the kitchen in the back part of the house.

Fig. 11.5: Petra, ez Zantur I with the glass sets used in living rooms and kitchens and the display of better quality glass tableware in the front part of the house (D. Keller).

Glass vessels in the Late Roman house

The distribution of glass vessels within the Late Roman houses at Ephesus and Petra indicates that glass tableware was kept in the kitchen as demonstrated by housing unit 4 of terrace 2 at Ephesus (Fig. 11.1), Petra ez Zantur III and Petra ez Zantur I (Figs 11.4–11.5), in small rooms adjacent to the kitchen as at Petra ez Zantur IV (Figs 11.2–11.3), or in small rooms near the dining and reception rooms as illustrated in housing unit 4 of terrace house 2 at Ephesus (Fig. 11.1), the *domus* of terrace house 1 at Ephesus and Petra ez Zantur IV (Figs 11.2–11.3). The reason for this was probably to facilitate the transport of glass tableware to the dining rooms by either keeping them in the vicinity of the dining rooms or in, or next to, the kitchen where they could have been used to convey prepared food from the kitchen to the diners. This pattern has already been observed in some houses in Pompeii and it seems to be a common practice for the storage of tableware in the Roman house. Ideally, this needs to be tested with larger datasets. However, these rooms do seem to be logical places for keeping such tableware. They are ideally located next to food preparation or consumption areas and are in obvious thoroughfares to facilitate the movement of food and drink in each of the respective buildings.

Another observation can be made regarding the glass vessels from the Late Roman houses at Petra. The good quality glass tableware or the more expensive imported glass vessels were found in the dining rooms of the houses on ez Zantur IV (Figs 11.2–11.3) and ez Zantur I (Figs 11.4–11.5). However, in room 6 on ez Zantur IV, which was one of the two main dining/reception rooms of the house, not only was good quality glass tableware recovered but also a series of ceramic cooking/storage vessels, two fine ware ceramic bowls, a lid of an incense burner (Gerber 1998, 272–275, figs 16–18) as well as a wooden box containing scales (Dozio 2005, 21). This array of artefacts suggests that this particular room served different functions. The presence of the incense burner in conjunction with the architectural layout suggests that the room was used as a reception room and a dining room. Therefore, the good quality glass drinking vessels could have been stored here and, when required for dining, more glass tableware could have been easily brought to room 6 from nearby rooms where glass tableware was kept (Fig. 11.3). On the other hand, the good quality glass vessels could also have been used for display in the most public reception room of the house, along with the scales, which appear to be an important item kept in the same room. The importance of displaying good or better quality glass tableware in reception rooms may also be highlighted by the respective finds from room 2 on ez Zantur I (Figs 11.4–11.5). In this smaller house, the contrast between the better quality glass vessels in reception room 2 and the common glass vessels in the living rooms or the more private living areas is very clear. Furthermore, there is another set of better quality glass tableware in the entrance room 4 of the house, indicating the display of better quality glass vessels in the public area of the house.

It may be suggested that the concept of different qualities of glass vessels is a modern one and the implications are not valid for the Late Roman period. However, in the price edict by Diocletian in AD 301, an Alexandrian and a Judaean group of glass vessels were mentioned in terms of value, the former being more expensive. This seems to indicate the existence of two qualities of Late Roman glass, a cheaper one and another which is more expensive, representing a better quality product (Barag 1987, 113–116; Stern 1999, 460–466). Perhaps more relevant to illustrate the use of different qualities of glassware in the Late Roman household is a law text of the early 3rd century AD. Paulus orders in the Digest, that ‘glass vessels for eating and drinking are to be considered in the class of the household goods, just as earthenware vessels are, not only the common ones, but also those that are more costly’

(Paulus, *Digesta Iustiniani* 33,10). This confirms the use of better quality glass tableware alongside the usual, more common, glass vessels in the Late Roman household.

The archaeological record at Petra suggests that the better quality glass vessels were displayed in the dining/reception rooms on ez Zantur IV and ez Zantur I as well as in the entrance room on ez Zantur I, *i.e*. the public area of the house, whereas the standard-quality glass was either used in private areas of the house as on ez Zantur I or kept in convenient places to supplement the better quality glassware for larger meals as on ez Zantur IV. That good quality glass tableware was displayed in public rooms can also be demonstrated with the finds from the main reception room of the *domus* of terrace house 1 (Czurda-Ruth 2007, 221, 227–228, no. 15, pl. 31.15) and from the peristyle of housing unit 2 of terrace house 2 at Ephesus (Schätzschock 2010, 592–594, pls 247, 260.1). As there is no evidence for cupboards or chests in the public rooms at these locations, the good quality glass tableware was not only kept in these rooms but appears to have been openly displayed, most likely on wooden shelves or tables. Such a display of glass tableware can be seen on Roman funerary monuments in the north-western provinces of the Roman Empire: for example, glass jugs and cups are displayed next to a dining scene on the frieze of the southern side of the 3rd-century AD tomb monument at Igel, Germany, with metal or pottery plates on the other side of the dining scene (Dragendorff and Krüger 1924, 73–74, fig. 43, pl. 9.1). Similar depictions are also known from fragmentary tomb monuments at Neumagen, Germany (von Massow 1932, 136, 197–198, nos 180b, 260–262, pls 28.180b, 50.260–261). The importance of exhibiting glass tableware can also be seen on the interior decoration of the 3rd-century AD sarcophagus from Simpelveld, Netherlands, on which a glass flask and three glass cups are displayed on a shelf of an open cupboard (Holwerda 1931, fig. 18b; Galestin 2001, 64). The frieze on the Igel tomb monument depicts a dining scene from real life, but the Simpelveld sarcophagus 'is not a frozen moment in time nor an illustration of the interior of a particular room, but instead contains objects considered important for the deceased' (Galestin 2001, 68). Therefore, it is legitimate to conclude that glass tableware could have been a showpiece and a status symbol used to represent the Late Roman way of dining.

For the houses on ez Zantur this means that in the large house on ez Zantur IV a set of good quality drinking vessels was displayed in the dining/reception rooms, whereas in the small house on ez Zantur I similar sets were kept in the dining and in the entrance room. The example from the small house on ez Zantur I is especially interesting as it is the glass bowl which appears to be the main vessel used in the private living rooms. Its multi-functional form is suitable for the lower social level and more intimate use, whereas in the public rooms the inhabitants displayed sets of glass beakers similar to those from the dining rooms in the large house on ez Zantur IV. Therefore, it appears that the lower social classes living in the small house on ez Zantur I imitated the drinking customs of the higher status occupants by displaying the relevant glass vessels in the public part of their house.

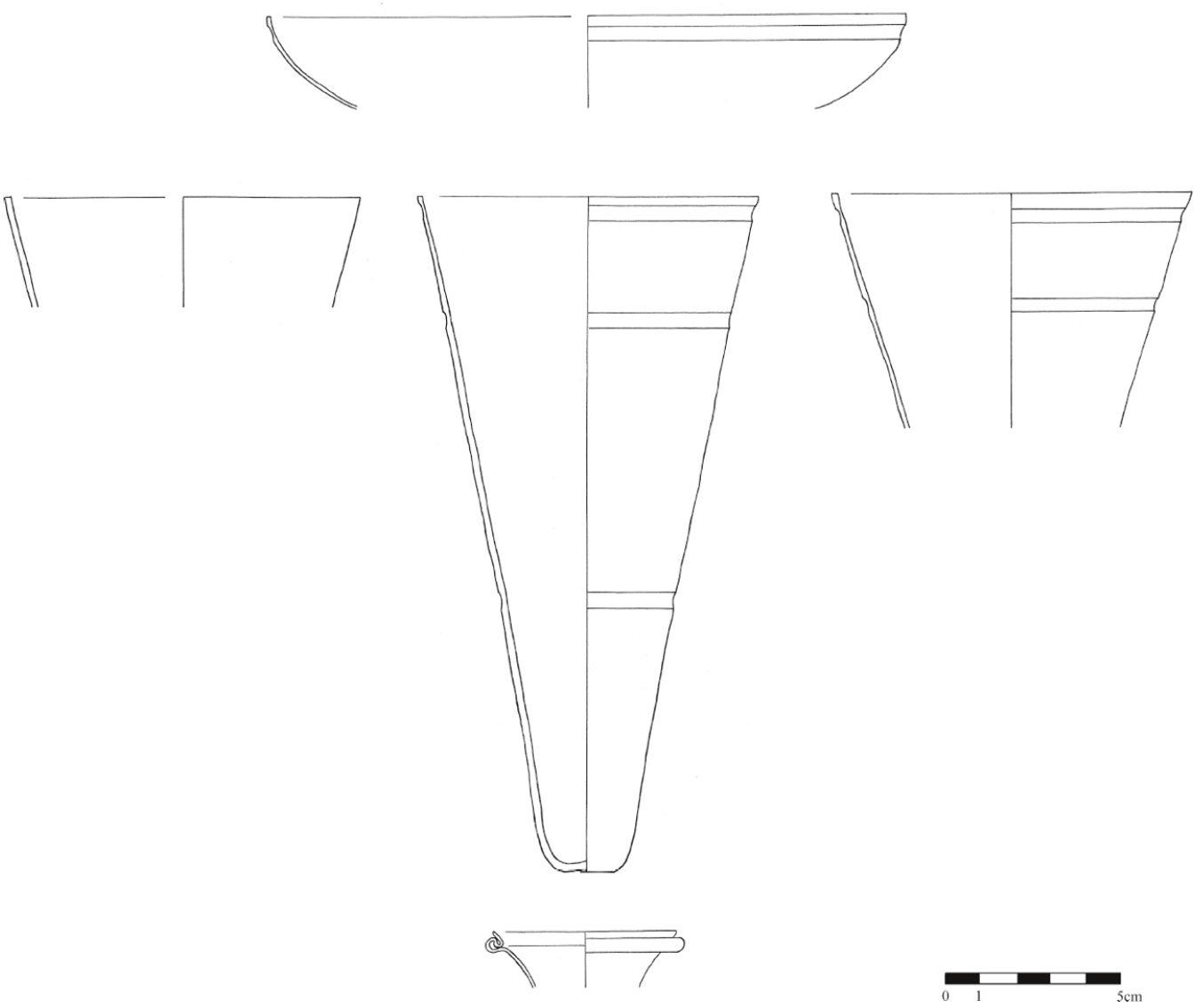

Fig. 11.6: Late Roman glass tableware set 1a from room 6 on ez Zantur IV, Petra (D. Keller).

Reconstructing the use of Late Roman beakers

Glass beakers were not only showpieces in the Late Roman household, they also had their practical use in Late Roman dining. It could be suggested that only three beakers per set is too few, especially considering the large dining rooms in the house on ez Zantur IV, in which certainly more than three people could have dined (Figs 11.2–11.3). However, the glass beakers themselves (Fig. 11.6) offer a solution to this problem. They are large in size, with a capacity for holding up to 500 ml of liquid. Furthermore, their conical shape and small base did not make it possible to put them down when they were filled. Therefore, rather than being for individual use, they were probably passed from one guest to the other during dinner.

This hypothetical reconstruction of the use of such large glass beakers finds its confirmation in depictions on Late Roman monuments: in the Igel dining scene two couples are sitting at a table, the two men passing on their beakers to the two women (Dragendorff and Krüger 1924, 73–74, fig. 43, pl. 9.1). Furthermore, a series of Late Roman mosaics illustrate this dining custom, as examples from Ostia, Italy (Kondoleon 2000, 184–186, no. 68), Piazza Armerina, Italy (Dunbabin 2003, 147–148, fig. 86), Carthage, Tunisia (Dunbabin 2003, 89–90, figs 46–

47), Ephesus (Dunbabin 2003, 164–165, fig. 97), Shaba/Philippopolis, Syria (Dunand 1926, 335, pl. 68) and Sepphoris, Israel (Dunbabin 2003, 166, pl. 12) demonstrate. Here glass beakers are being passed from one guest to the other, and at the most only three beakers are depicted although there are a large number of guests (compare Keller 2006, 177–178 notes 964–969). A 4th-century AD painting in a tomb at Tomis, Rumania, also shows a dining scene with five guests, but only two conical glass beakers in use (Dunbabin 2003, 168, pl. 13). Similar dining scenes are also depicted on Late Roman silver plates (Dunababin 2003, 141–146, figs 84–85, pl. 8) and Late Roman sarcophagi (Amedick 1991 passim), but in these cases it is difficult to decide whether the beakers are made of glass. Glass beakers are depicted on at least two sarcophagi (Amedick 1991, 122, 164, nos 8, 267, pl. 34.2–3) as their conical shapes are decorated with typical wheel-cut lines. However, as the 4th century AD is generally the period in which glass beakers replace ceramic beakers, it can be assumed that in most cases the depictions represent beakers made of glass (compare Keller 2006, 178 note 972). However, whether they are glass or not, these depictions confirm the common Late Roman way of dining using only a few large beakers and passing them around many people. The glass beakers from the Late Roman houses in Petra can therefore be set into the context of this Late Roman drinking custom.

Homogeneous versus heterogeneous glass tableware sets

Sets of glass tableware used in Late Roman houses do not necessarily have to represent a homogeneous set of glass vessel types, where all the vessels are of the same size, style and design. Of course, homogeneous sets were found, such as sets 1a–c containing three good quality beakers from the house on ez Zantur IV (Fig. 11.6; Keller 2006, 143, fig. 63) or sets 3d, with glass bowls with blue trails, from the house on ez Zantur I (Keller 2006, 161, fig. 77). Yet, in contrast, the large tableware sets 3a–c from the house on ez Zantur IV consist of bowls, beakers/cups and jugs of different types (Keller 2006, 145, fig. 66). Similarly, the three beakers of the tableware set 2a from room 14 on ez Zantur IV belong to three different vessel types of two glass qualities (Keller 2006, 144–145, figs 62, 65), and the sets 1c and 2a in rooms 2 and 4 on ez Zantur I also consist of beakers and cups of different types and qualities (Keller 2006, 157, figs 72, 74–75). The latter sets offer an explanation for the occurrence of heterogeneous beaker sets, as it was obviously important to have sets which comprised three (or in one case four) glass beakers. Ideally, the three or four glass beakers would be of the same beaker type and quality and so this would constitute the original composition of the set. However, if a beaker was broken, it would have to be replaced by another, preferably of the same style as the original set, as might have been the case in the house at ez Zantur IV where a considerable number of glass beakers of good quality were present (Figs 11.2 and 11.6). However, if the house owner was less prosperous, then the broken vessel may have been replaced by a beaker of a different shape, and sometimes even quality, as was the case with some arguably less important sets on ez Zantur IV, and with the representative glass tableware sets on ez Zantur I. It can therefore be suggested that in these cases, it was more important to have the required number of beakers to complete the set, but less important to have them all in the same style.

The homogeneity of glass tableware sets is related to the act of ordering or buying them from a glassblower or his shop respectively. The presence of heterogeneous sets illustrates acts of use. Thus, in these examples the dynamic process of the use of glass in sets can be observed, where the number of vessels and the shape and function of vessel were more important than the actual type or design of the vessel; hence functional and not formal

aspects influenced the composition of sets. A similar pattern emerges from the composition of Late Roman silver tableware, which was also not influenced by formal homogeneity but rather by functional aspects of general vessel shapes (Guggisberg 2003, 250–251).

That glass tablewares could have been bought initially as homogeneous sets is confirmed by two 2nd-century AD papyri from Egypt which note that specific sets of glass tableware were ordered (Grenfell and Hunt 1904, 239–240, no. 741; Youtie and Winter 1951, 24–33, no. 468; compare Stern 1999, 471–472). Moreover, glass drinking vessels from the cargo of a late 2nd–early 3rd-century AD shipwreck at Embiez-Ouest, Southern France, are packed in groups of five (Foy and Nenna 2001, 110). This latter example may reflect the way of packing the glass for the transport rather than implying sets consisted of five vessels, as Roman tableware sets contain usually two, three, four or six vessels of the same type, *i.e*. parts of a dozen (Drexel 1921/22, 37–38; Drexel 1927, 51; Garbsch 1982, 8; Guggisberg 2003, 251–252 notes 996–1001). However, the composition of a glass tableware set could have changed during the time of its use, which is reflected sometimes in the heterogeneous composition seen in the archaeological record.

Thus, by studying tableware assemblages from *in situ*-contexts of domestic houses which were inhabited for a considerable length of time, the end of the life cycle of such glass tableware can be revealed, rather than the beginning. On the other hand, promising studies by Price *et al*. (2005) and Freestone *et al*. (2009) on the glass tableware from Stonea in Cambridgeshire, England, revealed a set of glass vessels which was produced from the same batch of glass and was thus acquired together at this site. This offers another avenue of research and conversely illustrates the origin rather than the end of the life cycle of glass tableware sets.

Summary

The contextual analysis of the Late Roman glass finds from Ephesus and Petra reveals several points. First, Late Roman glass tableware was either kept in or near the kitchen, or in small rooms close to the dining/reception rooms of the relevant houses, thus facilitating their movement to their place of use. Second, good quality glass tableware which was kept in the dining/reception rooms or the entrance room of a house could have been used as a showpiece and perhaps even as a status symbol, suggesting that glass vessels played an important role in late Antique dining and society. As glass beakers were the most common drinking vessel in the Late Roman period, good quality glass beakers could be regarded as an indicator of social standing or wealth within the Late Roman household, especially when displayed in the public area of the house. At a lower social level, multi-functional glass bowls might replace the glass beakers in the private, less public, areas of the house. Third, the number of glass beakers per tableware set and their respective size indicate that they were passed from one guest to the other during dining, hence providing evidence for a particular way of dining in the Late Roman period. This way of dining can be reconstructed mainly in the richer households, but was obviously copied in the reception areas and more public parts of the houses owned by members of the lower social class. Finally, the glass tableware sets from *in situ*-contexts do not necessarily reflect sets which were originally purchased together, as their composition may change during the time of their use in a household, hence transforming the set from an originally homogeneous to a heterogeneous mixed style set.

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12

A ROMAN DIONYSIAC CAMEO GLASS VASE

Martine Newby Haspeslagh

Introduction

Just as this volume was being completed, a newly identified Early Imperial Roman two-handled cameo glass vase came to light (Figs 12.1–12.4). It is now the thirteenth Roman cameo vessel known, the largest, and the most complicated in its decoration. The Vase dates from the late 1st century BC to the first half of the 1st century AD, but until the technique of manufacture of the cameo blank is determined and further parallels to the iconography and decoration are found, it is not possible to be more precise. Its first presentation was as a poster followed by a short lecture at the 18th Congress of the International Association for the History of Glass (AIHV) in Thessaloniki in September 2009 and I am very pleased that I am able to publish it here for the first time in Jenny Price's Festschrift. As my supervisor for my MPhil and friend for many years she has always been very encouraging with my research and generous with her considerable knowledge. This certainly will not be the Vase's last publication, and the theories about how it was made and its iconography will probably change and develop as more research is undertaken. This paper, therefore, is very much a preliminary account of this remarkable vessel. It is also fitting that it has been included here as Jenny Price was present not only at the inspiring colloquium on Roman cameo glass organised by Paul Roberts in the British Museum in November 2007, indeed she gave the final summary, but also when the Vase was taken to the Museum to be compared alongside the Portland Vase and the Auldjo Jug. From an immediate examination of the photographs here it is possible to see that it is indeed very closely related to both these vessels.

One immediate question it raises is whether this Vase could reflect the original shape of the Portland Vase, which was broken in antiquity and repaired with a cameo base disc (Harden *et al*. 1987, 59–60; Roberts *et al*. 2010, 34–43). In his study of the Portland Vase, Dennis Haynes (1964, 14) considered the possibility of it having had a flat base with a moulded rim like that of the Auldjo Jug (Harden *et al*. 1987, 79; Roberts *et al*. 2010, 43–7), before concluding that it was more likely to have had a pointed bottom as on the Blue Vase in the Museo Archeologico Nazionale, Naples (Painter and Whitehouse 1990, 138–40), a view held by many other scholars. Among these was Donald Harden, but he later came to believe that as the Portland Vase had an ovoid rather than a cylindrical body it would look better proportionally with a flat bottom (Harden 1983, 53; Harden *et al*. 1987, 57 and 60). In addition, like the Blue Vase and the present Vase, the Portland Vase originally had a second short frieze around its lower body, whatever its form. William Gudenrath and David Whitehouse (1990, 109) have further

suggested that if the Portland Vase had a base knob it would have been between 330 and 370mm high, a similar height to this Vase.

Provenance and condition

Unfortunately the early history of the newly-discovered Vase is not known. It was consigned to the auctioneers Bonhams in the spring of 2009 for research and conservation by the daughter of a late European collector, the rest of whose collection had already been dispersed by them. She believes that the Vase entered her father's collection in the late 1940s, a gift from an Italian family friend, but it was kept in storage rather than on display. The exact circumstances are currently being researched by Bonhams and earlier papers about it are being sought.

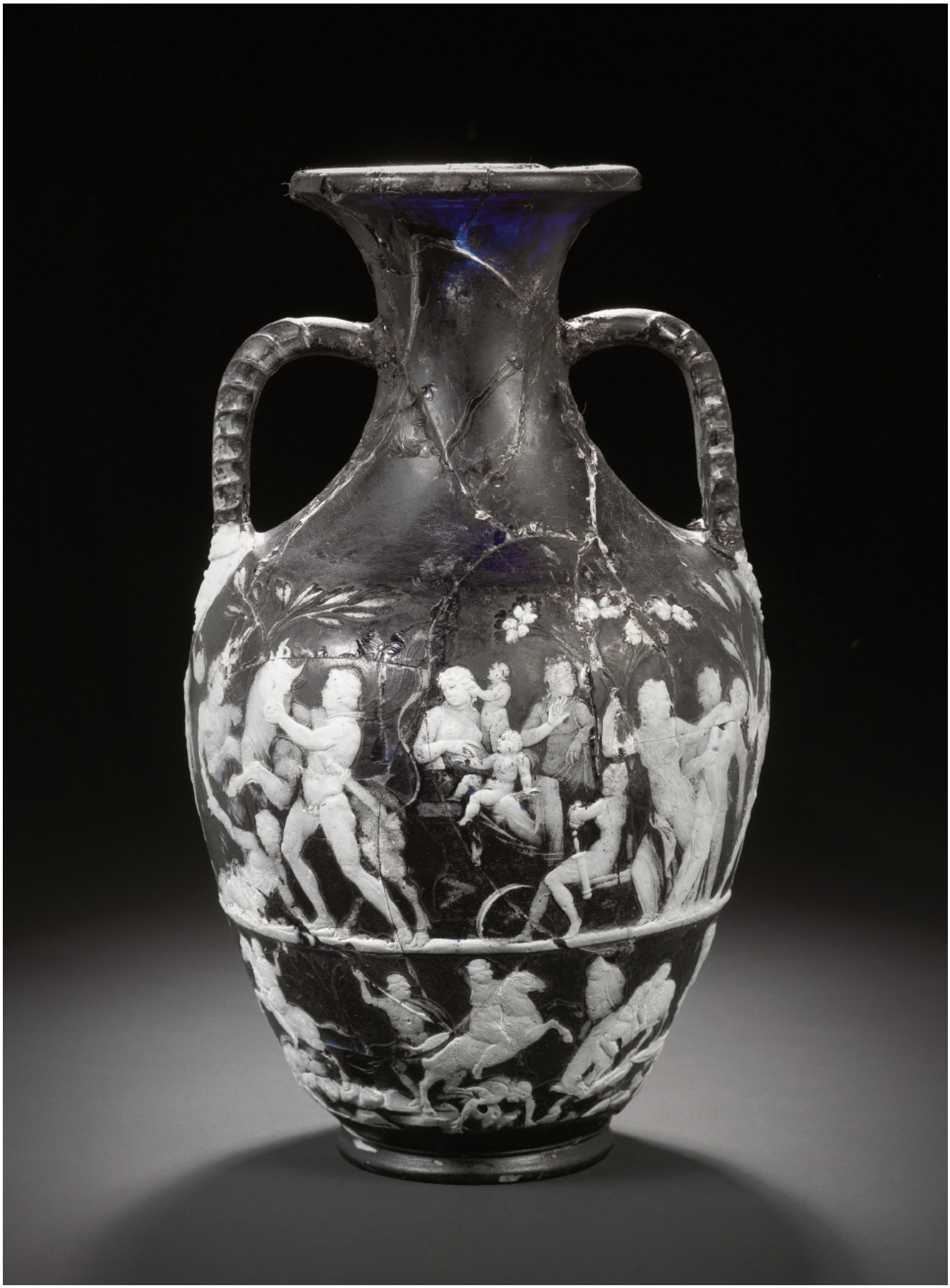

Fig. 12.1: Side 1 of the cameo glass vase. Photograph © Bonhams

The Vase is broken and has been restored seemingly at least three times, while some of the breaks and chips appear modern as if it has been broken more recently. There are traces of old brown animal glue along the more major breaks. It was then repaired using a clear resin and finally with light pink plaster filling the missing pieces and the wider gaps between the fragments. Indeed, the first photographs I saw showed the Vase, especially the upper neck and mouth, restored in pink plaster, but by the time it arrived in London this had been coloured dark blue by marker pen. Furthermore, some of this blue colouring had also spread over the white wheel-cut decoration, but this will all be removed during restoration.

The only areas with traces of the original limy weathered surface are the underside of the handles. This would have given the Vase a stone-like appearance when first found. Elsewhere the weathering has been removed mechanically and scratches can still be seen on the neck. The interior of the mouth has also been polished and the weathering removed but there is a cream-coloured layer visible on the rest of the interior. When a strong light is shone through from the outside, the breaks are visible so this could be the original weathering layer rather than some sort of plaster wash added during the last repair. When the Vase is restored more information about the weathering and its earlier phases of restoration will come to light.

Fig. 12.2: Sides 1–2 of the cameo glass vase. Photograph © Bonhams

Description

The vase stands 355mm high and is made in dark blue glass, appearing black, with an opaque white overlay. The flaring mouth has a rim with a rounded profile, *circa* 9.5mm thick, and a diameter of 117mm. In the interior below the rim there are three concentric wheel-cut grooves (max. diameters: 104.5mm, 99.5mm, and 94.5mm). It has a short cylindrical neck above sloping shoulders and a body tapering inwards towards the flat bottom with an applied base-ring. The underside of the base still has the original polishing marks.

Both handles are broken and have been reapplied to the neck, but originally the lower attachments were applied over the opaque white overlay. The opaque white is very thick at this point and it is possible that an opaque white coil was applied around the attachment; certainly the masks (see below) are cut in relatively high relief compared to the rest of the decoration. Evidence for the form and decoration if any of the upper handle attachment is also lacking but it is unlikely that there was a raised lozenge-shaped panel as on the Portland and Blue Vases. Yet, like the handles of the former, the outsides are also wheel-cut with overlapping V-shaped sections.

Fig. 12.3: Side 2 of the cameo glass vase. Photograph © Bonhams

Decoration

The design must have been copied from a model or drawing and, unlike the Portland Vase, no surface below the level of the handles was left undecorated. The decoration was cut into the opaque white to leave two figural friezes against a dark blue background. Furthermore, some of the figures appear to have a raised blue outline, a result of the opaque white weathering away, while other parts, including some of the layered rocks, trees, and drapery, were intentionally cut in relief in the blue to add further depth to the decoration. The twenty-five figures in the upper frieze appear to form two related scenes on each side, all on a continuous ground-line, and separated by the tragic Dionysiac masks with fruiting ivy wreaths below each handle. At this stage it is unclear how these scenes relate to each other or to the battle frieze below. It is also uncertain as to which side was intended to be viewed first, but as further study identifies the figures and scenes all these relationships will become clearer. There are also five trees in the upper frieze that fill the space behind the figures and make a canopy above them. There are two smaller trees, more like shrubs, in the lower battle frieze that has eighteen figures. In total there are forty-three figures. The numbers in square brackets below relate to the different figures depicted in the upper frieze on the vase and are provided so that authors may refer to these in future publications.

Fig. 12.4: Sides 2–1 of the cameo glass vase. Photograph © Bonhams

The first scene has seven figures (Figs 12.4 and 12.1). First, a clean-shaven muscular youth [1] grasps the wrist of a lightly-draped woman [2] who is pushing herself up from the ground to preserve herself from the hooves of a large muscular bull [3] above (Fig. 12.5). This bull is restrained by the right horn and mouth by a second handsome cleanshaven muscular youth [4] who wears a short sword at his side. Beyond him, to the right, the bull's long tail is curled upwards, separating the first part of the scene from the watchful gaze of a woman [5], seated on a layered rocky outcrop, with her twin children [6 and 7]. Her fingers are disproportionally large, a discrepancy that occurs in many of the hands and feet of the figures on this vase. This scene almost certainly shows the punishment of Dirce, with the woman on the ground the unfortunate queen. The two youths on either side are Amphion on the left, identified by the lyre hanging from the tree branch behind him, and Zethus on the right. This arrangement of these three figures and bull can also be seen in the 'Farnese Bull' marble in the Museo Archeologico Nazionale, Naples, and in the fresco in the House of the Vetii in Pompeii. The identification of the mother as Antiope with Amphion and Zethus as children is more tentative and the reason for one of them wearing a cap is uncertain.

Fig. 12.5: Part of scene 1 showing figures [1]–[4]. It almost certainly depicts the punishment of Dirce [2], with Amphion [1] to the left and Zethus [4] to the right holding the bull [3]. Image width 125mm. Photograph © Bonhams

The second scene (Figs 12.1 and 12.2) is also observed by two figures on the left: a lightly draped woman [8] with her right hand raised in a gesture of alarm rather than greeting, and below, a seated Amazon [9] who holds the straps for a short sword that rests against her left thigh. There is also a circular shield at her feet that is leaning against the rocky outcrop on

which Antiope(?) is seated. Her dress is very similar to some of the figures on horseback in the battle frieze below. In the main part of the scene a maenad (or an effeminate Dionysus?) [10] holds an upturned thyrsus in her right hand, while her left hand rests on the shoulder of a distressed woman [12], who is also being restrained by a clean shaven youth [11] with short, wavy hair. This woman has her head downturned, slumped shoulders, and arms hanging down in an attitude of distress at the departure of the bearded warrior or hero [13] on the right. He is shown pulling away from her although he clasps her with his right hand, while looking directly at the maenad [10].

Fig. 12.6: Left hand part of the third scene showing figure [14]; either the young Apollo or Orpheus. Image width 87mm. Photograph © Bonhams

The figures of the third scene (Figs 12.2 and 12.3) are dominated by the naked muscular and clean shaven youth [14] set slightly apart on the left. He is depicted sitting on a layered rocky outcrop with his lower legs crossed (Fig. 12.6), with a lyre made from an animal's skull, similar to that hung in the tree to the left of Amphion [1]. At his feet is a small hound [15]

sitting on its hind quarters, its tail between its legs and its head upturned towards its master. Next is a tree with a thin trunk that separates the seated figure [14] from a second clean shaven warrior or hero [16] with a short sword and long spear, who is looking and pointing at another seated figure [18]. At his feet a woman [17] is kneeling on the ground, her head turned upwards towards him, her arms raised and palms upturned as if pleading. Next, in slightly smaller proportion, is the figure of a clean shaven and muscular young man [18] with short wavy hair, seated on a layered rocky outcrop while surveying the scene to his right. To his left is an even smaller lightly-draped female attendant (?) [19], with her forefinger to her mouth in a gesture of consternation. The first figure [14] is either the young god Apollo with his lyre or Orpheus, while the rest of the scene might show Ariadne being abandoned by Theseus on the island of Naxos and overlooked by the seated figure of Dionysus.

Fig. 12.7: Part of the battle scene on the lower frieze of the vase. Image width 85mm. Photograph © Bonhams

The last scene (Figs 12.3 and 12.4) depicts some sort of Dionysiac festival or procession, possibly even a marriage. The first figure is a clean shaven Bacchant [20], walking towards the right but looking backwards at the pleading woman [17]. He is holding a large krater with a gadrooned lower body over his left shoulder and is wearing a wreath of long leaves in his short wavy hair, a spotted (leopard?) skin tied around his neck by the paws, and a hairy animal hide tied around his waist. He is preceded by a lightly-draped female attendant [21] who is bent over to hold up the hem of the dress of the central and largest figure of this scene [22]. This is another lightly-draped maenad who is holding a *thyrsus* tied with a ribbon over her left shoulder and a (wedding?) ivy wreath with a long veil in her right hand. To her left is a tree with a slender trunk in which a canopy has been tied over figures [23–25] to the right. These last three figures comprise a lightly draped plump figure [23] playing the double flute, her long hair secured by a plaited headband or diadem, a putto [24] holding a *liknon* on his head, and finally, a lightly-draped maenad [25] with an ivy wreath in her hair, holding a lighted torch in her right hand and a *thyrsus* tied with a ribbon in her left. If the previous scene could represent the abandonment of Ariadne by Theseus, this last scene could show Ariadne after her wedding to Dionysus and her initiation into the Dionysiac mysteries.

That the scenes in the upper frieze are probably wholly or partly Dionysiac should not come as a surprise as at least seven of the other fifteen surviving cameo vessels or panels also have Dionysiac scenes. These include the skyphos in the J Paul Getty Museum, Malibu (Painter and Whitehouse 1990, 143–5, no. A4), the Morgan Cup in The Coming Museum of Glass (*ibid*. 141–3, no. A3), the bottle from Torrita di Siena in the Museo Archeologico, Florence (*ibid*. 145–7, no. A5), the Besançon Jug (the only vessel in purple glass; *ibid*. 146, 148–9, no. A6), the two panels from Pompeii in the Museo Archeologico Nazionale, Naples (Harden *et al*. 1987, 70–3, nos 32A and 32B), and the Cameo Carpegna in the Louvre, Paris (Painter and Whitehouse 1990, 160–1, no. A14). The Portland Vase could be an eighth example, depending upon whether the viewer accepts the identification of the scenes as showing episodes from the myth of Theseus, Ariadne and Dionysus.

Fig. 12.8: The base of the vase showing two small areas of opaque white glass embedded in the dark blue just above the base ring. Photograph © Bonhams

The lower frieze has a continuous battle scene with eighteen figures, including five on horseback armed with spears or short swords (Fig. 12.7) and five dead bodies. Four of the figures on horseback could be Amazons wearing short tunics and laced sandals, but it is not possible clearly to identify their sex. All the six horses (one has no rider) are shown with bridles and with animal skins on their backs. The figures on the ground engaged in battle include two naked swordsmen with shields protecting their left sides and short swords raised above their right shoulders about to strike, while another is seated on a rocky outcrop with his rounded shield on his head. There are also two spearsmen with helmets and shields, one of whom is bearded, an archer wearing a short tunic and sandals, and finally a figure wearing a loincloth and holding double pipes standing beside a wounded or dying horse. Who is fighting whom is confused and it is unclear if the frieze is a generic scene rather than an actual battle from history or mythology.

Technique of manufacture

At the AIHV Congress I suggested that the Vase may have been free-blown because of the elongated bubbles aligned vertically in the blue glass, a feature identified by William Gudenrath and David Whitehouse (1990, 108–9) in the Portland and Blue Vases. The largest of these bubbles is 130mm long, considerably larger than those encountered on other ancient cameo glass vessels. This very large bubble burst as the overlying opaque white was removed and may clearly be seen in Figure 12.3 between the maenad [22] and her attendant [21] holding up her mistress's hem, and extending down into the battle scene below. Indeed, the upper arm of the maenad holding the wedding veil is hollow underneath. There are several other places on the Vase, especially on the lower body, where bubbles in the blue glass have burst, possibly while it was being decorated, causing the glass-cutter to alter the design or to smooth the edges of the bubble.

The opaque white overlay has considerably smaller yet still slightly elongated vertical bubbles. If blown, this could indicate that the main body of the Vase was almost fully formed before the opaque white was applied, covering it from the base to above the level of the lower attachment points for the handles. How this overlay was applied still needs to be determined although it is interesting to note that there are two areas of opaque white embedded into the blue on the cut edge of the base immediately above the applied base-ring. These are visible at the bottom left of the vase (Fig. 12.8). David Whitehouse has described a similar phenomenon on the Morgan Cup and on the skyphos in the J Paul Getty Museum, which has led him to suggest that this might indicate that the opaque white on these two vessels at least was applied as a thick spiral trail (Whitehouse 1991, 27–9).

There are also small elongated and vertically aligned bubbles in the interface between the blue and the opaque white which, in the case of the Portland Vase, William Gudenrath believes resulted from the failure of the opaque white glass to flow fully into depressions on the surface of the blue paraison as the two layers of glass were being gently inflated (Gudenrath and Whitehouse 1990, 111). Gudenrath also notes that 'many of the interface bubbles appear to be arranged in a large vertical patch, a result of upward progress of the white glass as the blue cylinder was being pushed into it.' This could also, however, be indicative of Mark Taylor and David Hill's theory that the Vase was instead formed around some sort of shaped solid core rather than by blowing (*pers. comm.*). I am grateful to them both for sharing their ideas with me and look forward to working with them when the Vase is dismantled so we can really investigate how it was made.

On the Portland Vase, William Gudenrath believes that the handles were pressed into the neck and then re-attached into the lower shoulder, while noting traces of blue glass extending down the sides of the Portland and Blue Vases. On this Vase, however, these traces are not visible, and the shoulders are raised at the point of the lower handle attachment as if the solid cylinder of blue glass for the handle was first applied to the shoulders and then drawn up and attached to the side of the neck. It is also interesting to note that there are no cut chevrons as on the other two vases (Gudenrath and Whitehouse 1990, 114).

What's Next?

At the time of writing this short paper, I am continuing to work on the iconography and the Vase's probable technique of manufacture. The owner has agreed that it be conserved, and it is hoped also to analyse the two glasses, the glues and the weathering deposits. When completed, a full catalogue will be prepared and the newly restored Vase will be exhibited at Bonhams later in 2010. What will then happen is as yet unknown.

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I would like to thank the following for helping me with my research to date: Sir John Boardman, Sally Cottam, Ian Freestone, Marie-Do Nenna, Kenneth Painter, Maddy Perridge, Lisa Pilosi, Jenny Price, Paul Roberts, Chantelle Rountree, Mark Taylor and David Hill of the Roman Glassmakers, as well as many of the delegates to the 18th AIHV Congress and the photographers and designers at Bonhams who produced the poster for the Congress.

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13

AN UNUSUAL MOULD-BLOWN BEAKER FROM BARZAN, SOUTH-WEST FRANCE

Sally Cottam

Amongst the extensive catalogue of published research by Professor Price, one of the most frequently cited articles is the brief but comprehensive survey of mid-late 1st-century AD mould-blown tableware, in the volume arising from the 1987 conference in honour of Donald Harden (Newby and Painter 1991). There, she discusses the origin and distribution of mould-blown vessels and outlines technical aspects concerning their manufacture. It is noted that while the bases of most cups and beakers were formed in multipart body and base moulds or by using a separate base piece, 'a few vessels were blown into body moulds without abase piece' (Price 1991, 58). This short article will discuss one such vessel, found during excavations in south-west France in the summer of 2007.

Excavations at the Moulin du Fâ near the village of Barzan on the northern shore of the Gironde estuary (Charente-Maritime) have uncovered the remains of a substantial Roman town (Bouet 2003 and 2011). The site is dominated by the circular podium of a large Gallo-Roman temple, upon which stands the 16th-century windmill that gives the place its name. Nearby, a large public bath-house was discovered, along with a variety of other residential and commercial buildings and a purpose-built 'entrepôt' with warehousing and storage cellars. The town seems to have thrived on commercial enterprise, linking the inland city of Saintes with important trading routes into central France via the Gironde estuary, and along the Atlantic coast.

A considerable quantity of Roman glass has been recovered from the bath-house and the adjacent areas (Dubreuil 2003; Cottam 2011). The assemblages date from the 1st-early 3rd centuries AD, and include a particularly large and interesting group of late 1st- and early 2nd-century tableware.

The two fragments under consideration here come from a blue-green mould-blown drinking vessel, probably a beaker, from a context dating to the second half of the 2nd century AD or later (Fig. 13.1). They are small pieces, one from the body, the other from the lower body and base of the vessel. Both retain part of a mould-blown design in low relief. Despite the dating of the context in which it was found, characteristics of form and decoration place this beaker in the second half of the 1st century AD.

When complete the vessel, in common with other forms of mid-later 1st-century beaker, probably had a vertical or slightly curved rim with a ground edge, and a straight-sided body. The small concave base has a narrow tubular pushed-in base-ring. Tubular pushed-in base-

rings are quite common on mid-late 1st-century cups and beakers, but are usually a feature of blown, not mould-blown vessels. This combination of mould-blown body and pushed-in base-ring is a relatively rare and intriguing feature. There is no doubt that the body of the Barzan beaker was formed in a mould, though no trace of a mould seam is visible on these fragments. Very little of the decoration survives. There is a horizontal cordon on the lower body and base fragment, marking the edge of the decorated zone, and a trace of a vertical line from a further mould blown motif above. The body fragment has two rows of close-set shield-shaped motifs in low relief arranged in quincunx as overlapping scales, with the rounded edge probably at the top. It is not possible to tell whether these rows are repeated over the entire body. If they were, this vessel might resemble a conical mould-blown beaker from le Chastelard du Lardier near Avignon in south-east France which has rows of closely-set raised ovals arranged in quincunx, above a horizontal cordon. In published reconstructions of the vessel (Foy and Nenna 2001, 81 no. 78; 2003, 249 fig. 72), this cordon is considered to indicate the edge of a flat mould-blown base, but it may simply border the lower edge of the decorated zone, as on the vessel from Barzan.

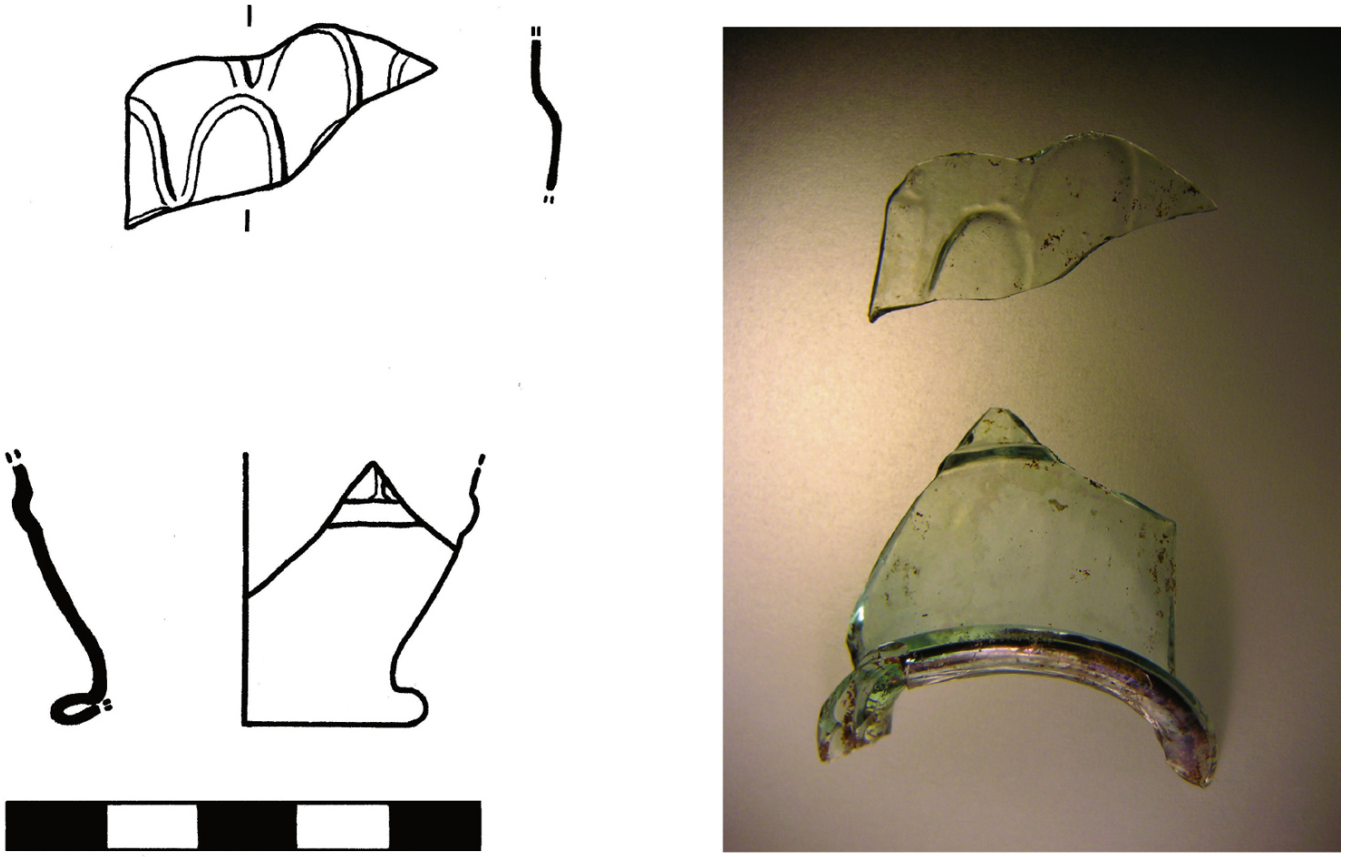

Fig. 13.1: Fragments of mould-blown beaker from Barzan, Charente-Maritime. Scale bar 50mm.

The combination of mould-blown body and tooled base is found on a few other vessels, but is not common (Fig. 13.2 shows the find spots of comparable vessels from elsewhere in the western Empire). A complete pale green conical beaker, of uncertain provenance, but perhaps found at Stoke Bruerne, Northamptonshire, England appears to have been produced in a similar manner (Brown 1968). This vessel, now in the Ashmolean Museum, Oxford, is decorated with rows of bosses surrounded by inverted tear-shaped motifs in low relief (Fig. 13.3). Unlike the Barzan beaker, which has an undecorated band on the lower body above the base-ring, the mould-blown decoration on the Ashmolean Museum's beaker extends right

down to the base edge. The profile of the lower body is also more straight-sided than the Barzan beaker, the latter tapering in significantly to the base ring.

At least two other beakers with mould-blown bodies and tubular bases are known from Pompeii (Eisen 1927, 289–90, 293, fig. 130, pl. 63; Borriello 1989, 220–1, no. 24, right, no. 25; Beretta and Di Pasquale 2004, 218, 1.55). One is decorated with a vine scroll, grapes and birds, and another greenish colourless beaker has bands of contrasting motifs including, on the lower body, a horizontal bifoliate wreath above a horizontal cordon. On the latter example, only a very narrow undecorated area lies between the cordon and the base ring. Part of a mould-blown beaker with similar decoration on the lower body comes from Rubí, near Barcelona in north-eastern Spain, and this too has a tubular base-ring (Price 1974, 68, no. 1).

Part of the body and base from a pale blue mould-blown vessel with a tubular base-ring was found during excavations at Luni, north-eastern Italy (Roffia 1977, 288, CM 7465 fig. 157.5). This has part of a meandering vegetal scroll on the lower body. In Sicily, the body and base of a colourless vessel with vertical S-shaped motifs and ivy tendrils came from excavations at Solunto (Basile *et al*. 2004, 80, no. 127, Tav XXXIII).

Examples are also known from sites on the north-western frontier. The lower part of a colourless mould-blown beaker with a pushed-in base came from a Flavian pit in the canabae of the legionary fortress at Nijmegen in the southern Netherlands (van Lith 1995, 135, no. 5). The beaker is decorated with an angular meandering line, encasing ovals. This vessel was regarded by van Lith as being a locally produced item. The quality of the glass was noticeably poor, being very bubbly and dotted with black specks and it was therefore considered unlikely to have been imported from a distant manufacturing centre. Another lower body and tubular base fragment, from Ladenburg in Baden-Württemberg comes from a greenish beaker with tear-shaped motifs alternating with long ovals and possibly shells. The piece comes from a context dating to the military (later 1st century AD) period of occupation at the site (Hoffmann 2002, taf.54 L37, 80 B5, 366 B6).

These beakers undoubtedly have very strong connections with the truncated conical mould-blown beakers with flat bases found quite frequently in later 1st-century AD contexts in many parts of the Roman world (Isings 1957, 45–6, form 31; Price 1991, 70, pl XVIII b–c, XIX; Stern 1995, 103–110). The types of motif present on the vessels discussed here, such as wreaths, meanders, ovals and vine scrolls, are also found on beakers of the flat-based form. The range of colours used is similar, and where evidence for the mould is visible, as on the example from Solunto, it appears that the body was also blown into a two-piece mould. It is very possible that they were being made in the same workshops as their flat-based counterparts, using the same moulds. This raises the question as to how the tubular base was formed, and why it occurs on a limited number of these vessels.

Experimentation in making this sort of beaker by Mark Taylor and David Hill at their workshop near Andover suggests that the simplest way to form the tubular base is firstly to blow a complete vessel into a mould with a flat base piece, as if forming a regular mould-blown beaker. The paraison is then removed from the mould and the end is carefully reheated and then manipulated to produce a tubular base. All traces of the moulded base are eradicated during this process. Blowing the paraison into a mould with body pieces but no base piece produces an over-expanded bubble of glass at the end of the vessel which cannot be easily reheated and worked into a tubular base ring.

It appears that only a small number of mid-late 1st-century mould-blown beakers were provided with a tubular base, the vast majority having bases formed by the mould. It might be suggested that these tubular bases were added in an attempt to cover up an error in the moulding of the base. This seems unlikely, as although there is certainly a very visible mistake

in the alignment of the body moulds on the beaker in the Ashmolean Museum in Oxford, there seems to be no evidence of moulding errors on the other examples.

The answer is more likely to be related to trends in drinking vessel design in the second half of the 1st century AD. The beaker from Barzan, though it has unusual decoration, provides a perfect illustration of some of the developments in glass tableware manufacture taking place during this time. During this period, conical and straight-sided drinking vessels become more common with the introduction of new forms, including mould-blown beakers, facet-cut beakers, indented beakers and arcaded beakers (see Cool and Price 1995, 213–5 for an overview of some of these developments). Many of these new forms feature tubular base-rings, previously rather uncommon on blown and mould-blown drinking vessels. These tubular bases are characteristically narrow, slightly out-turned and rather small, generally around 40mm in diameter. Drinking vessels in the later decades of the 1st century are also often highly decorated. As well as the complex designs seen on mould-blown drinking vessels, a number of techniques are employed in the decoration of blown beakers, including facet and relief-cutting, vertical, diagonal or looped trails and indents (Price and Cottam 1998, 80–8)

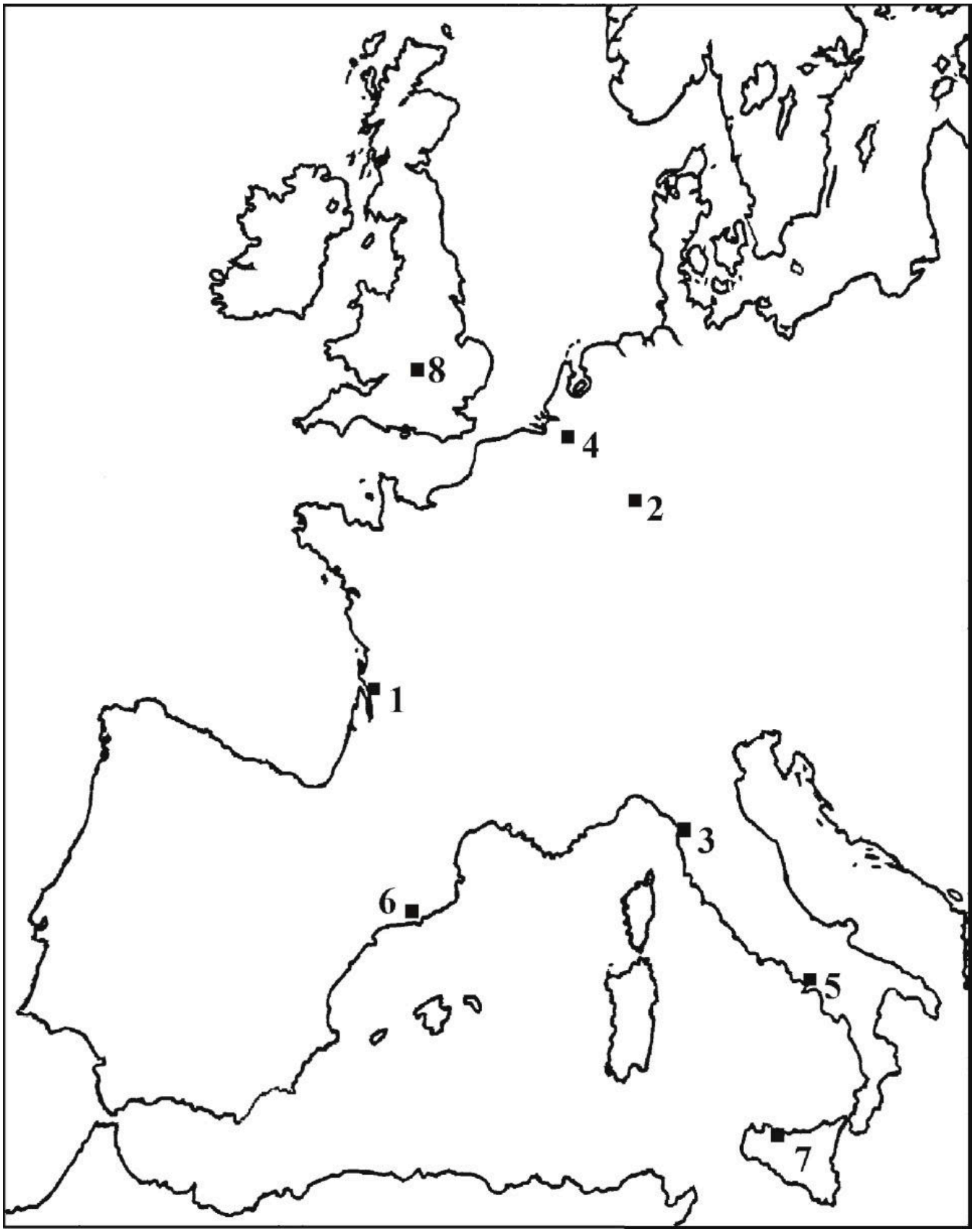

Fig. 13.2: Findspots of examples of mould-blown beakers with tubular base-rings from Western Europe. 1. Moulin du Fâ, 2. Ladenburg, 3. Luni, 4. Nijmegen, 5. Pompeii, 6. Rubí, 7. Solunto, 8. Stoke Bruerne.

The beaker from Barzan brings together several of these trends in form and decoration in a single vessel. It has the small tubular base-ring found on blown vessels of the same period, whilst the straight-sided body shows the type of highly decorated surface noted on both blown and mould-blown beakers. The presence of an undecorated zone on the lower body, below a horizontal cordon and above the base, is reminiscent of some facet-cut beakers. These features place it firmly amongst contemporary later 1st-century AD drinking vessels from the Roman west. It could perhaps be a product of a regional workshop such as that at Saintes, about 25km north of Barzan, where fragments from blown conical beakers with similar narrow tubular bases were found amongst late 1st-century glass-working debris (Hochuli-Gysel 2003, 184–5, fig. 18 no. 4).

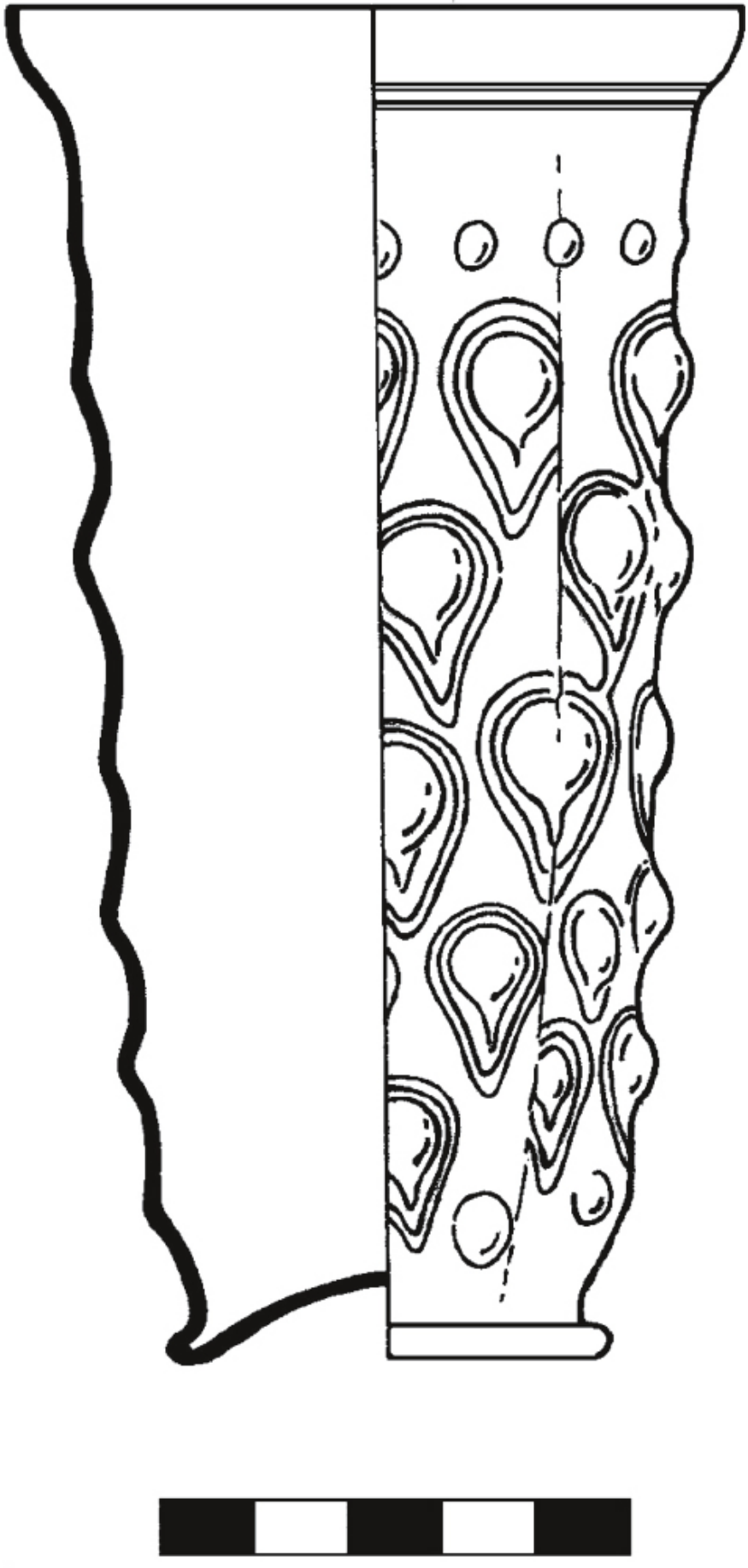

Fig. 13.3: Mould-blown beaker from Stoke Bruerne, Northamptonshire. Scale bar 50mm.

Several of the beakers mentioned in the discussion above were kindly drawn to my attention by Professor Price. More of these vessels will no doubt appear in the course of further excavation and research, perhaps including examples from eastern provinces, bringing with them the pleasant prospect of further discussion of this subject.

Acknowledgements

I would like to thank Professor Alain Bouet (Université de Toulouse II), the director of the excavations at Barzan. Mark Taylor and David Hill (romanglassmakers.co.uk) took the trouble and time to re-create similar vessels and discuss how they might have been manufactured. André Kauffmann kindly gave me access to study the mould-blown beaker from le Chastelard du Lardier, now in Apt Archaeological Museum. I would also like to thank Professor Michael Vickers and the curatorial staff at the Ashmolean Museum, Oxford for providing information about the likely provenance of the mould-blown beaker from Stoke Bruerne and allowing me to draw the vessel.

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Section 3: Other Uses of Glass

14

FLAT GLASS FROM BUTRINT AND ITS SURROUNDING AREAS, ALBANIA

Sarah Jennings†

This article presents a preliminary report on the flat glass from the excavations at Butrint, the adjacent areas of Butrint's suburbs across the Vivari Channel on the Vrina Plain, and at Diaporit further up the lake. Work is still in progress on the excavations, post excavation work, and recording of the flat or window glass, so final phasing for all the sites and quantification of the flat glass is not yet available, but sufficient work has been completed to present this interim statement.

Butrint

The ancient port of Butrint is situated on the south-west coast of Albania, directly opposite the island of Corfu, in the region known in antiquity as Epirus (Fig. 14.1). It occupies a small hill at the end of a narrow peninsula that divides the Ionian Sea from the large saltwater Lake Butrint, which is linked to the sea via the narrow Vivari Channel. The town was founded in around the 8th century BC and became a Roman colony under Augustus (Hansen & Hodges 2007). The Roman town expanded beyond the confines of the earlier settlement to the opposite side of the Vivari Channel, covering around 32 hectares at its zenith. The heart of the town was the sanctuary of Asklepios, which appears to have been a popular cult centre within the region. By the end of the 3rd century AD, however, the sanctuary had declined and Butrint during the later 4th to 6th centuries (Bowden 2003; Hodges *et al*. 2004, 92), like many other towns in the Mediterranean, had changed dramatically. Fortifications were constructed in c. 480/500 AD, possibly in response to Vandal raids on the Epirot coast (Andrews *et al*. 2004, 126–50), as protection against the 'barbarian' tribes who were raiding the Balkans with increasing frequency during the late-Roman period, and a number of large Christian buildings were constructed within the walls.

By the mid-7th century, the town seems to have been effectively abandoned. During this period it is not certain if it was a Byzantine bulwark in an otherwise Slavic area, or if indeed it was in Slavic hands. Nothing more is heard of Butrint until the late 9th century, when the area was rescinded to the Byzantines (the surviving Eastern Roman Empire), but certainly it was back in Byzantine hands when St. Elias passed through the port in AD 881, although the town does not seem to have revived significantly until the 13th century. In the 14th century it fell

into the hands of the Angevins and subsequently became a part of the Venetian Empire. In the 17th century Butrint came under the control of the Ottoman Turks, who effectively held the town until its final demise in the 19th century, when it was abandoned due to the malarial condition of its surroundings. By this time it had dwindled to a small fishing settlement, surrounding a Venetian castle.

The current series of excavations at the UNESCO World Heritage Site of Butrint, Albania, started in 1994 and has been undertaken by The Butrint Foundation Project in collaboration with the Packard Humanities Institute under the direction of Richard Hodges and Ilir Gjepali, vicedirector of the Albanian Institute of Monuments. The first major excavations in Butrint were undertaken in the late 1920s by the Italians and archaeological excavations continued through the Communist era, but this article only covers material from the excavation programme undertaken since 1994.

Site ref Site code + <context>	Group	Average min thickness within pane (mm)	Average max thickness at edge (mm)	Average weight grams/cm^2	Weight code
FOR <72>	1	4	6	1.42	C
VP3 <5053>	1	3	5.2	1.12	C
VP1.1 <83>	1 sub gr	1.3	3.7	0.55	B
VP4 <7163>	1 sub gr	1.8	2.5	0.54	B
VP3 <5112>	2	1.4	2.1	0.40	A
VP4 <7163>	2	1.2	1.3	0.31	D
VP Tr4 <3945>	3	1.5	2.0	0.41	A
VP4 <7163>	3	1.8	2.0	0.47	A
BUT03 <5014>	3	3.5	4.5	0.77	C
BUT03 <5269>	3	2.9	4.0	0.87	C
VP1 <16>	4	2.8	4.2	0.81	C
BUT00 <1439>	4	2.0	2.9	0.66	B
DIA <427>	4	2.7	5.0	0.95	C
DIA <980> Complete pane	4	2.8	3.2–5.2	0.73	C
BUT00 <1534>	5	2.0	2.5	0.60	B
DIA <133>	5	1.5	3.5	0.68	B
BUT00 <1114>	5	2.0	2.5	0.66	B
WD1 1021	6	4.6	10.6	2.09	C
VP <3347	6	2.9	8.9	1.36	C
VP 4 <3346>	6	3.3	8.3	1.3	C

Table 14.1. Window glass: Minimum and maximum thickness and average weight per square centimetre.

The window glass

Large quantities of flat glass fragments have been recovered from the current series of excavations from a number of different site types, and ranges in date from the 1st to 6th/7th

centuries AD with a small amount of later glass from the 8th to 10th or 11th centuries. The period terms used in this article, for example Late Antique (4th-6th centuries AD), are those defined for Butrint as a whole (Hodges *et al*. 2004, 80, Table 6.3).

A broad-base typology was established after a preliminary examination of the glass from three different areas in an attempt to understand and make sense of the large quantities of flat glass from a number of different sites and buildings with different functions, and a date range of at least six centuries. This resulted in the identification and definition of seven main Groups: Group 1, cast window glass; Groups 2–5 covering the commonly occurring cylinder glass of the mid-Roman and late antique periods; Group 6, a very small group of unusual late window glass, probably early medieval (7th to 9th centuries) only found in small quantities on two sites; and Group 7, crown glass dating to the high medieval period (10th/11th centuries). The four main groups of cylinder glass were established by considering the combination of a number of criteria – visual appearance, quality of glass, density of bubbles, colour, thickness, and slight differences in methods of manufacture. Cylinder glass Groups 2, 3 and 4 respectively broadly represent early, mid- and late production; Group 5, also cylinder glass, has as its main criterion a very distinctive darker green colour, and seems to fit in the earlier part of the late period production – Group 4.

Given the very fragmentary nature of this material and great variety of fragment sizes it was decided that the only viable method of quantification was by weight. By measuring in square centimetres the area of a number of larger fragments it was possible to establish four weight/area ratios which related to different thickness and to the different groups.

A = 0.35–0.50 grams/square cm
B = 0.50–0.70 grams/square cm
C = >0.70 grams/square cm
D = <0.34 grams/square cm; very thin fragments.

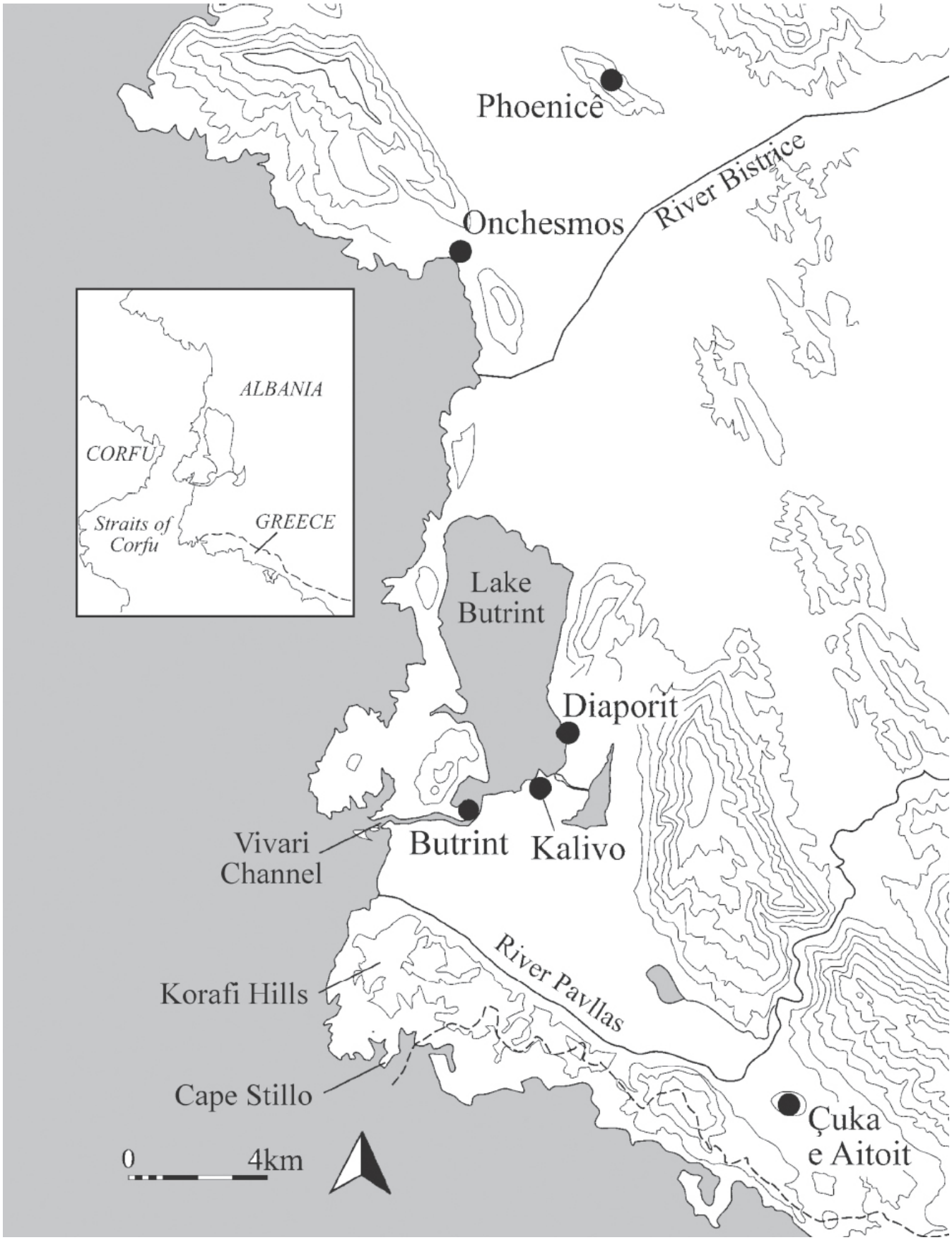

Fig. 14.1: Butrint and the surrounding region (Institute of World Archaeology). © The Butrint Foundation.

While this weight/area ratio can only be used to establish the approximate overall total area of a group of fragments, it is hoped it will provide an indication of the amounts of flat glass which have survived from different periods, or different buildings. Translating this into individual panes is also difficult as only one complete pane has been found, an example of Group 4, and it has only been possible to reconstruct the width of a couple of further panes but not their length. Weight as a form of quantification is least successful for the main type of Group 1 cast glass because of the significant variation in thickness between the edges and middle of a pane, but it does highlight the difference between the main group and the colourless cast glass subgroup where the weight ratio is about half. It clearly shows the very different amounts of glass used to make individual panes at different times (Table 14.1).

The development of flat glass found at Butrint follows the normal pattern of panes cast in trays, followed by panes made from blown cylinders opened up along their length and flattened out, followed by crown glass. However, crown glass is very rare and seems to be confined to the post-Roman period. The quantities and, more importantly, the quality of flat glass recovered from each site changes dramatically through the centuries, in part reflecting the types of structures and their use, but also the increasing availability of this commodity. This pattern of progressive increase is similar to the pattern of vessel glass availability and use. Some of the largest quantities of flat or window glass come from several late Roman or early Byzantine basilicas.

Fig. 14.2: Cast window glass with marks on the side and corner. Photograph J. Barclay-Brown. © The Butrint Foundation.

Group 1: cast glass

The earliest flat glass found at Butrint is the classic cast, or matt-glossy type made by pouring molten glass onto a flat surface and constricting it within a mould or frame to form the straight edges. The profile of the edges is also distinctive with one flat, dull surface while the upper surface is rounded and thick at the edge with the thickness diminishing towards the middle of the pane, and the whole surface smooth and shiny; corner pieces and some of the side fragments have the typical marks where the soft glass was pushed into the edges of the frame (Fig. 14.2). The quality of the glass of the cast panes in Butrint is generally good, transparent with few, mostly very small, bubbles. The earliest type of cast pane is thick and generally made from glass of a pale colour, but there is a definite sub-type made exclusively from colourless glass.

The colours of the earliest cast glass panes are always pale, blue/green, green or blue being the most common but occasionally also a faint grey tint, and with some pieces having a pinkish tinge probably from attempts to decolourise the glass, but truly colourless fragments are rare (Fig. 14.3 left and centre). Thickness typically varies from 4.2mm to 6mm at the edges and 2mm to 3mm nearer the middle of the pane, but panes made from bright blue/green glass are generally thicker, particularly in the centre where they are usually between 3.4 and 3.8mm thick. The distinctive features of the apparently later sub-type are that it is consistently thinner at both the edge and in the middle of the pane and is made from good quality decolourised glass with very few tiny bubbles (Fig. 14.3, right). Thickness at the edges is always less than 4mm, usually around 3.7mm but it can be as little as 2.5mm, while less than 2mm in the middle of the pane is standard and one pane was only 1.3mm thick. This sub-group has approximately half the weight per square centimetre of the earlier cast glass (see Table 14.1).

The general translucency of these panes is inhibited by the flat matt back which came into contact with the surface of the mould, but a light coating of oil would have improved this considerably (Jennifer Price pers. comm.). Provisional work indicates that window glass was first used in Butrint in the third quarter of the 1st century AD, and possibly by the mid-1st century, while the apparently later sub-type of thinner colourless cast panes probably first occurs in the early 2nd century. The colours of the glass used to make window pane glass reflect those found in contemporary blown vessels and the bright blue/green used to make the thickest panes seems to be identical to the vessel glass; the advent of the later colourless type mirrors the noticeable increase in colourless vessels in the late 1st to early 2nd centuries. Quantities of Group 1 are never high and most panes are represented by a single fragment suggesting that much of it was recycled. Cast window glass has been found from all excavated areas with deposits dating to the 1st century, but the later colourless panes have only been recovered from the Forum area in Butrint and one area on the Vrina Plain, south of the city (Fig. 14.1). How long cast window glass continued to be used is more difficult to determine largely because of a consistent residual element in many of the deposits, but certainly well into the 2nd century. No examples of circular bowl-shaped cast window glass with a central dome have been identified from Butrint so far (cf. Arveiller-Dulong and Nenna 2000, 219–20, nos 275–7).

Cylinder glass

Window glass made from blown cylinders was in common use in Butrint for a number of centuries and at least until the 7th century when the site went into decline. This type of flat glass was made by blowing as large and elongated bubble of glass as possible, which then was swung to stretch the bubble and further extend its length. This process results in any air

bubbles within the glass elongating down the length of the cylinder. The end of the bubble and the top near the blow pipe were removed, either by cracking-off or cut off with shears, and the resulting cylinder was split along its length, then opened-up and the sides allowed to fall flat producing a rectangular pane of glass (Newton and Davison 1997, 91–3). The exact way of doing the latter stages varied as evidenced by edges of the panes: some are square while others are fire-rounded from when either the cylinder or flattened pane was subsequently reheated. In some instances at least one of the shorter sides is fire-rounded while the long sides are square, showing that the cylinder was re-introduced to the furnace between the time when the end of the bubble was removed but before it was split along its length and flattened-out. The long square-edged sides are rarely completely flat and usually curve very slightly upwards along the line where the pane was split and has not completely flattened. In other cases none of the sides show any evidence of fire-rounding and are all square, but again the long sides have a very slight curve right at the edge while the short top/bottom sides are flat.

Fig. 14.3: Cast window glass colours, main group left and centre, later colourless sub-group right. Photograph J. Barclay-Brown. © The Butrint Foundation.

Fig. 14.4: Group 2 cylinder glass, late 2nd/3rd century. Photograph J. Barclay-Brown. © The Butrint Foundation.

Cylinder window glass from the main period of Butrint, roughly 2nd to 6th/7th centuries, has been divided into four broad types or groups based on a combination of colour, thickness, quality of glass, and small variations in techniques of manufacture. Only one of these groups, Group 5, has been defined by colour alone. It has usually been possible to attribute fragments

of even a fairly small size to a specific group, but inevitably a number of pieces have features, usually thickness but sometimes colour, of more than one group. Groups of fragments from a limited number of contexts on a single site are very occasionally not within the standard range for a specific Group, usually related to glass thickness, but are clearly part of it. It is possible that these represent a one-off supply from a different source.

Group 2: Roman cylinder glass

The earliest cylinder glass at Butrint, Group 2, usually has squared edges on all sides and is generally of extremely good quality. The best of the un-weathered fragments are completely transparent with very few, if any, bubbles and often with little discernible colour, but totally colourless pieces are uncommon and many have a very pale green tint (Fig. 14.4). The occasional occurrence of fine manganese streaks shows that the glass makers were attempting to produce as colourless a product as possible. Less common than pieces with a green hue are fragments with a very pale blue tint. Usually there is little discernible difference in this Group between the two surfaces although sometimes the inner surface of the cylinder is slightly shinier, and any marks on the back are rare. Although most of the edges of this earlier type of cylinder glass are square, occasional edges are fire-rounded while others appear to have been cut after the panes had cooled down and been annealed. The corners of some of the panes with square edges are slightly rounded-off (Fig. 14.4 centre right). The thickness of these panes is generally very consistent, between 1.5 and 1.9mm, with very few pieces being more than 2mm thick and with little variation across individual pieces. Some fragments of this square-edge type have more bubbles, although still not very many overall, and are slightly less transparent. This raises the question of whether panes of different quality commanded different prices, and whether they were preferred for different positions in buildings; some of the best quality window glass has been found associated with a bath house on the Vrina Plain.

A distinctive variation or sub-group of Group 2 has been found in several deposits from the Forum site. This was made in the same way as the main group and all the panes have cut edges, but it is extremely thin, typically less than 1mm with some fragments as thin as 0.57mm. Although the cut edges and colours of the glass, green and blue/green, are the same as panes from the main Group, unlike those these cylinders were consistently flattened on a slightly dirty or gritty surface. This has resulted in frequent small indentations on the outer surface of the cylinder which translates into an uneven upper or inner surface with tiny bumps due to the extreme thinness of the pane. Glass of Group 2 dates from at least the late 2nd century, but possibly earlier, and through the 3rd century.

Group 3: mid-Roman cylinder glass

By the 3rd century and into the 4th century the cylinder window glass in Butrint is far more variable and the quality is often less good (Fig. 14.5). In Group 3 the number of bubbles visibly increases, and can be very numerous, while the glass is generally less clear and often has minute inclusions, possibly indicating a higher level of recycling or simply that the raw glass available for the manufacturing process was poorer quality than it had been. The glass used for these panes is basically transparent, the surfaces are flat, even, and fire polished. The range of thickness of individual panes is much greater than that of Group 2, between 1.5 and 3mm (see Table 14.1), but generally with an even thickness across the pane fragments. Colours are pale, mainly near colourless, shades of green, pale yellow and occasionally very pale blue; the blue/green shades found in both Group 1, cast panes, and the earlier Group 2 cylinder glass, are uncommon. Edges are generally even and straight and both cut and fire-

rounded sides and top/bottom edges are known with fire-rounded edges being more usual on the top/bottom edge. The numbers of bubbles in panes of this period can be very variable in density but they are generally fairly small and even in size; there is no apparent correlation between colour and bubble density. Group 3 can be further subdivided based on the number/density of air bubbles – low, medium, and high – with medium being the most common.

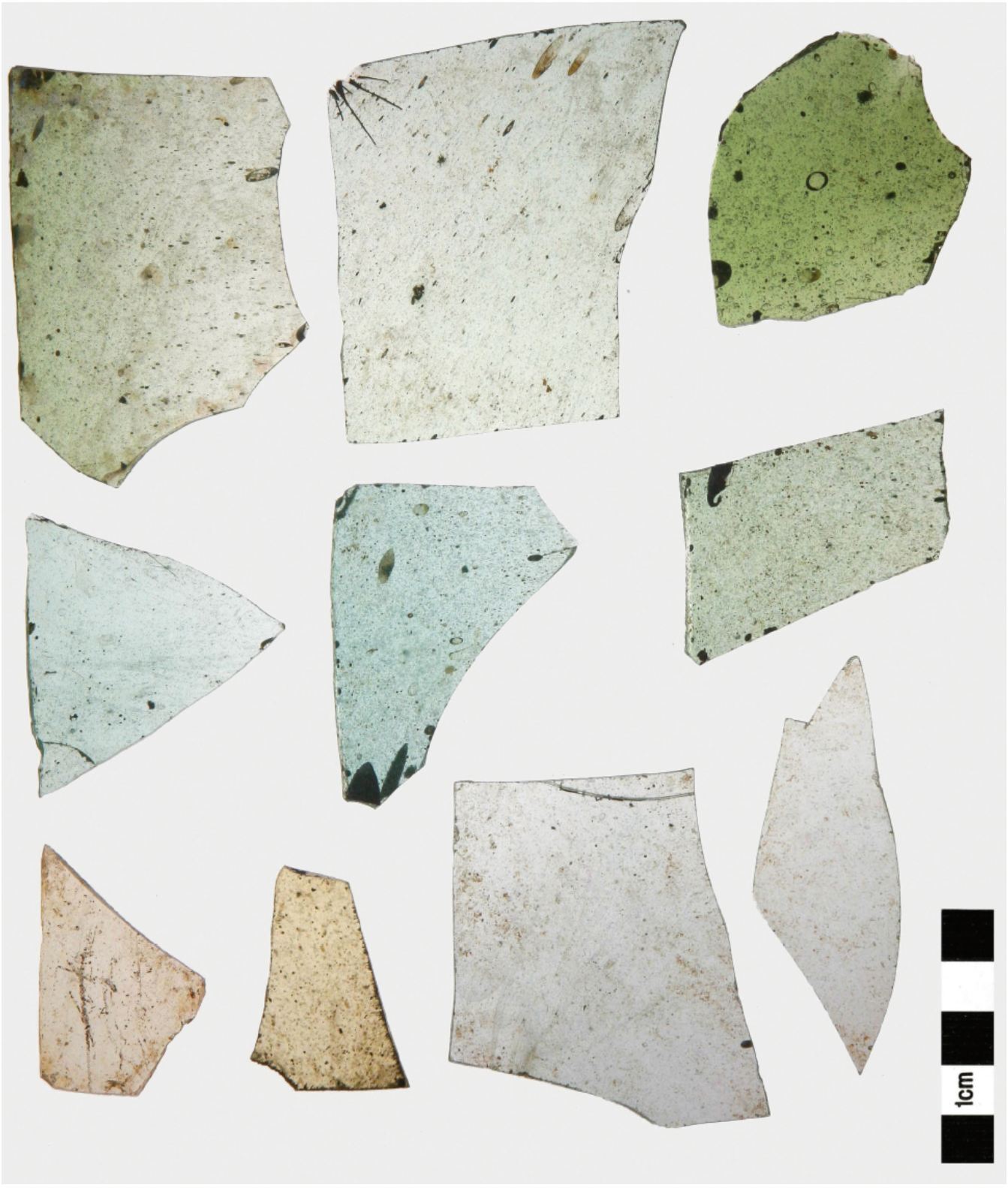

Fig. 14.5: Group 3 cylinder glass, mid- and late Roman. Photograph J. Barclay-Brown. © The Butrint Foundation.

Group 3 window panes were in common use in Butrint and the Vrina Plain and it looks as though this was probably a longer lived type than Group 2. It was certainly more varied with some panes twice as thick as others, and the clarity was less good. The correlation of glass colours and quality between vessels and window panes is less clear than in Group 2.

Group 4: late antique cylinder glass

The use of window glass in Butrint seemed to be very common during the late Antique period, and the frequency with which it is found in nearly every deposit indicates that most buildings, both public and domestic, had some form of glazing as standard. In the 5th and particularly the 6th century large deposits of window glass fragments are mostly associated with basilicas or churches, or other large buildings such as the Triconch Palace (Gilkes and Lako 2004, 151–75; Bowden and Mitchell 2007, 455–74). The find spots of these fragments shows that they came from the abandonment of such structures and do not represent collection of glass for recycling that has been identified in some places (Keller 2005, 69–74).

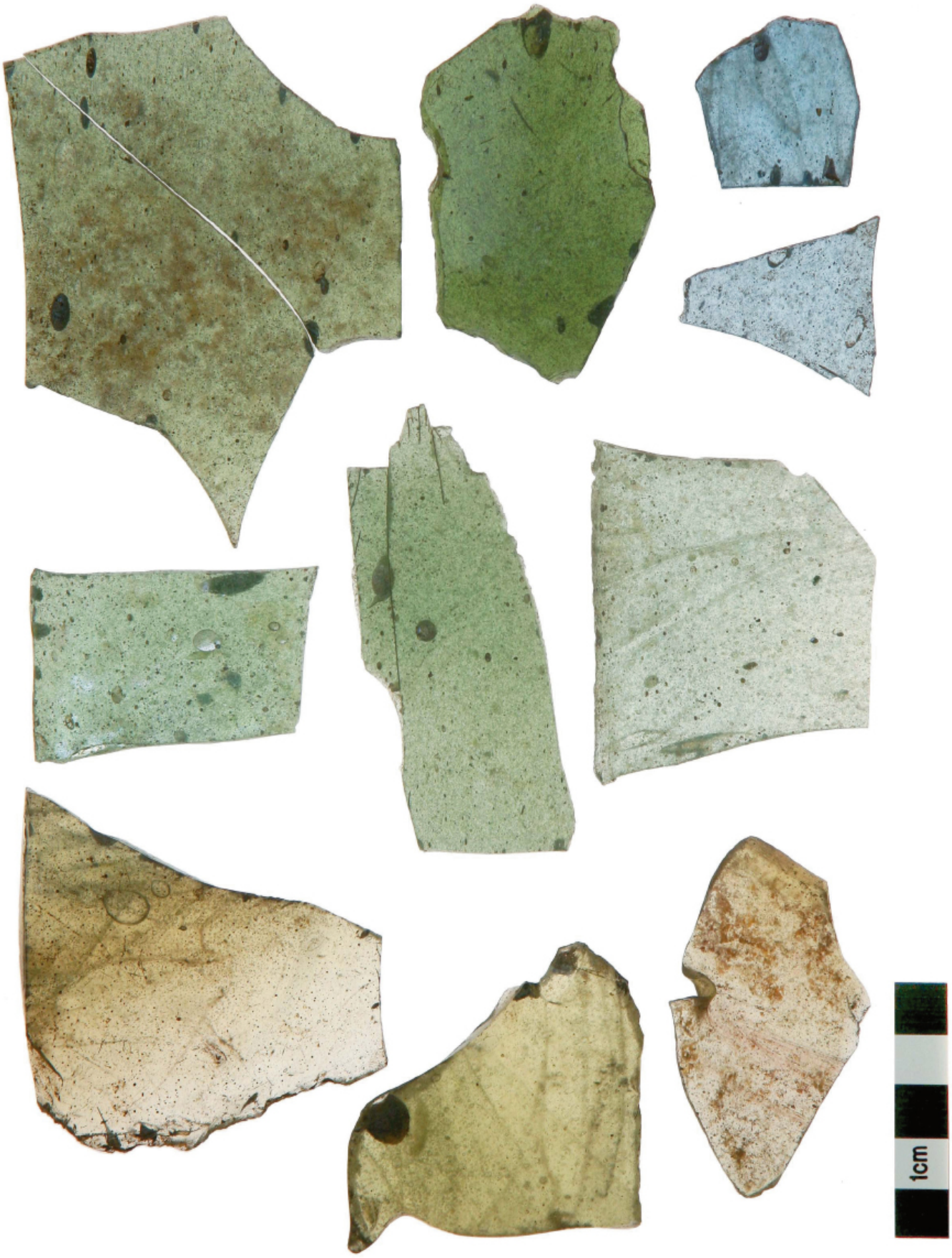

Fig. 14.6: Group 4 cylinder glass, late Antique. Photograph J. Barclay-Brown. © The Butrint Foundation.

Group 4, the latest of three main groups of Roman cylinder glass, has several distinctive features and by the 5th century the quality of cylinder glass had deteriorated dramatically (Fig. 14.6). Much of the flat glass is green to darkish green in colour (Fig. 14.6 centre top) and although attempts were made to decolourise some of the glass this is only evident in the pale yellowish-brown pieces; impurities in the glass itself are frequent, as are large elongated bubbles in addition to many smaller bubbles. Some fragments have such a density of small bubbles that they appear to be almost opaque. Thickness within each pane is often very variable and variations between 6mm and less than 3mm on the same piece are not unusual, and with some of the fire-rounded edges tapering even thinner. There is evidence from several pieces that on occasion more than one gather was used to make these panes (see below), something not seen in any of the other groups. How common this was is difficult to tell as it would not be apparent if the different gathers had properly fused together. Three pieces also show evidence of small areas of additional glass being added to the inner surface, most probably after the cylinder was opened up, presumably to patch thin areas or holes. The inner surface of the cylinder is fire-polished while the outer surface is duller from contact with the flattening surface, and swirls on the surface of the glass covering the whole of the back are common and particularly evident on weathered fragments, but still visible on unweathered surfaces. Rarely is either surface completely flat, in part due to the variations in thickness, but the back often has small indentations where it came in contact with occasional impurities on the surface onto which it had been flattened out. Although this late antique flat glass seems to have been made by the cylinder method with the typical lines of elongated bubbles running roughly parallel to the long sides, some of the edges are uneven where the soft glass has been manipulated by tongs or pincers and the edges pulled out so they are wavy rather than straight (Fig. 14.7). The uneven edges are usually found on what would have been either the top or bottom of the cylinder and these are fire-rounded. Maybe this is the result of attempts to manipulate and lengthen the cylinder after the end of the bubble had been removed, but before it was split open. The wavy lower edge of the complete pane (Fig. 14.11) is by no means unusual; several fragments have distinct pincer marks along the top/bottom edge and some of the thinner fire-rounded pieces even have partial folds (Fig. 14.8).

Fig. 14.7: Group 4 cylinder glass. Uneven top/bottom edges. Photograph J. Barclay-Brown. © The Butrint Foundation.

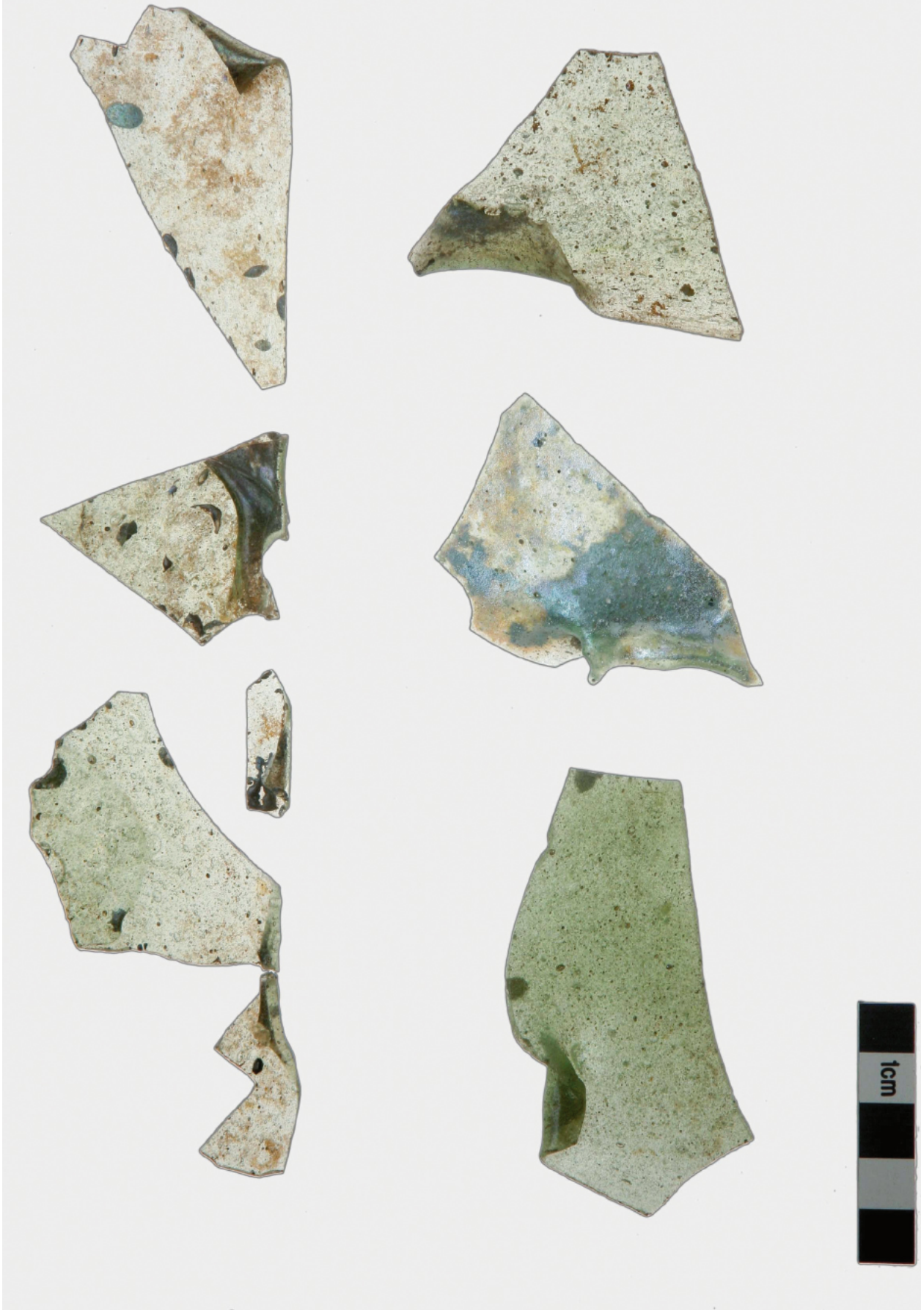
1cm

Fig. 14.8: Group 4 cylinder glass. Folded edges and corners. Photograph J. Barclay-Brown. © The Butrint Foundation.

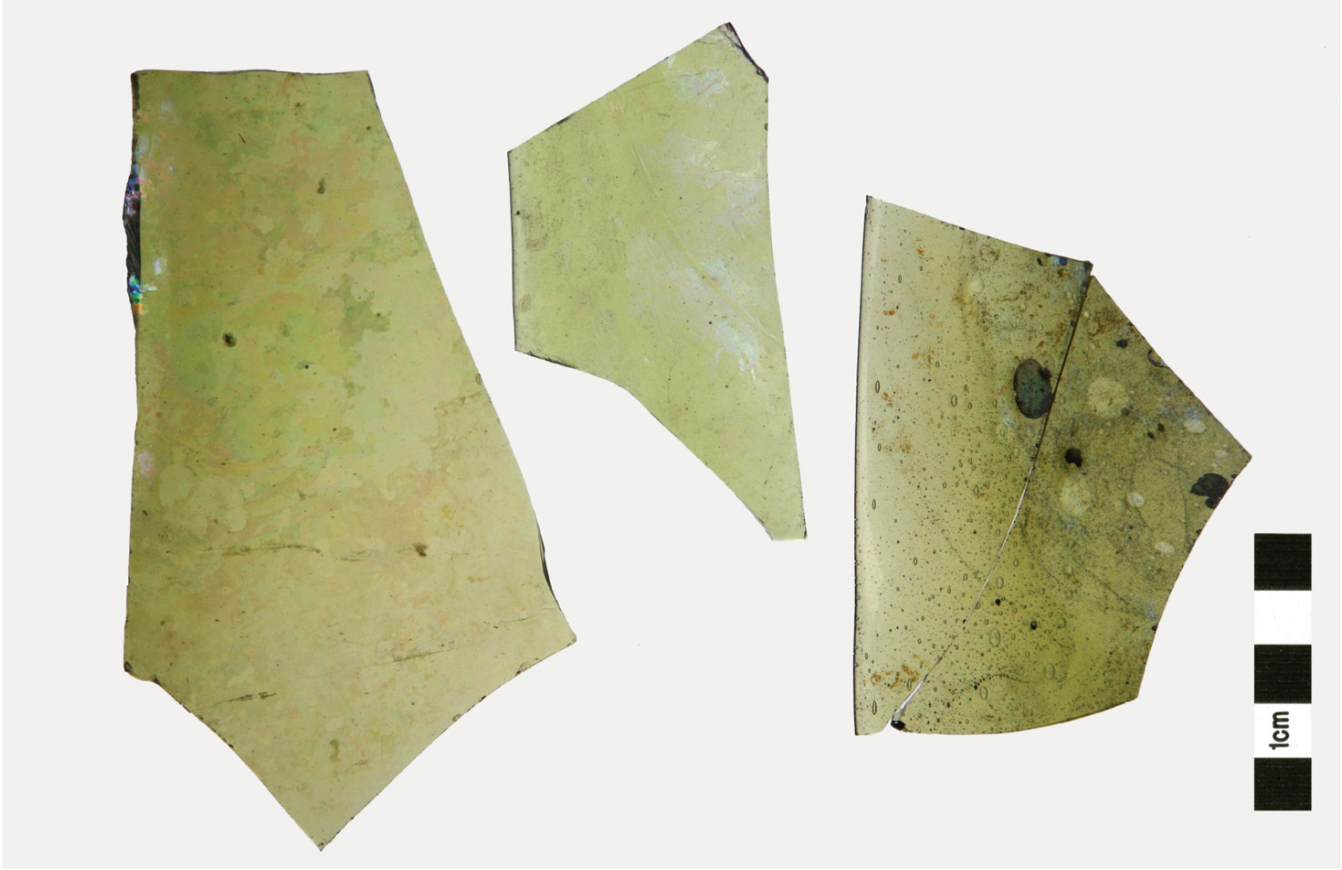

Fig. 14.9: Group 5 cylinder glass, late Antique. Photograph J. Barclay-Brown. © The Butrint Foundation.

Preliminary work suggests that the paler colours and better quality glass in this Group are likely to have been in use earlier, and colours got progressively darker over the decades as the two types are rarely found together. The dark colour of some of Group 4 and Group 5 (below), together with the semi-opaqueness of some panes, means that they would have let little light into a building.

Group 5: late antique dark green cylinder glass

Group 5 cylinder glass is a small group mostly found in the Triconch Palace but also occasionally at Diaporit. It is defined by its colour, a slightly yellowish dark green (Fig. 14.9), but is most closely linked to Group 4 with an average thickness of 3mm or more. Both surfaces are usually fire-polished but surface swirls have been noted on some fragments. The composition of Group 5 glass must be slightly different as it is rarely weathered, unlike most of the glass used for Group 4 panes, and glass quality and translucency is good. Side edges can be either cut with a slight edge curve (Fig. 14.9 left), or thin, tapering, and fire-rounded (Fig. 14.9 centre and right).

Group 6: early medieval window glass

Less than ten pieces of an unusual type of flat glass have been found and these have been classified as Group 6 (Fig. 14.10). All of them come from late deposits either on the Vrina Plain (later than the 7th century) or from Tower 1 on the Western defences where they were

found with a very large group of vessel fragments collected for recycling which date to c. 800AD (Jennings 2010). All the fragments that are definitely part of this late group were made from yellowish-brown glass and have edges that are thick, always more than 8mm and up to 10.6mm, and are thicker at the edge than the middle of the pane. One piece from the Western Defences has an uneven upper surface and a curved edge, 10.6mm thick (Fig. 14.10 top centre), but it is too small to tell if it is part of a disc that could have been formed by pouring or not. Another piece from the Vrina Plain has a thick, straight flat edge which tapers sharply from 10mm to 3.7mm in thickness towards the main part of the pane (Fig. 14.10 bottom left). Again it is unclear how this was made.

Group 7: medieval crown glass

Crown glass was made by blowing a bubble in the parison on a blowing pipe, the end of the bubble was then either opened up or cut off and reheated to soften the edge. It was then spun until centrifugal force stretched and flattened the glass and formed a disk. There is no evidence for the use of crown glass at Butrint until the 10th or 11th centuries, although crown glass of this type has been found as early as the 4th century at Jerash (Meyer 1987, 209). Only a few small flat and thin pieces with curved fire-rounded edges or rims have been found; two edge fragments are plain, thin and flat while a third edge of purple glass has a thicker profile on one side. These panes have diameters of around 25 to 30cms. Examples of crown glass with complete profiles and similar thin flat rims were recovered from the Serçe Limani wreck dating to c. AD 1025 and have diameters between 17 and 25cm (Bass *et al*. 2009). The few Butrint fragments from the Triconch are mostly deliberately coloured, either purple or dark greeny-blue, and only one virtually colourless fragment has been recovered. It is likely that these were set in plaster frames and were designed to let patterns of coloured light into a room.

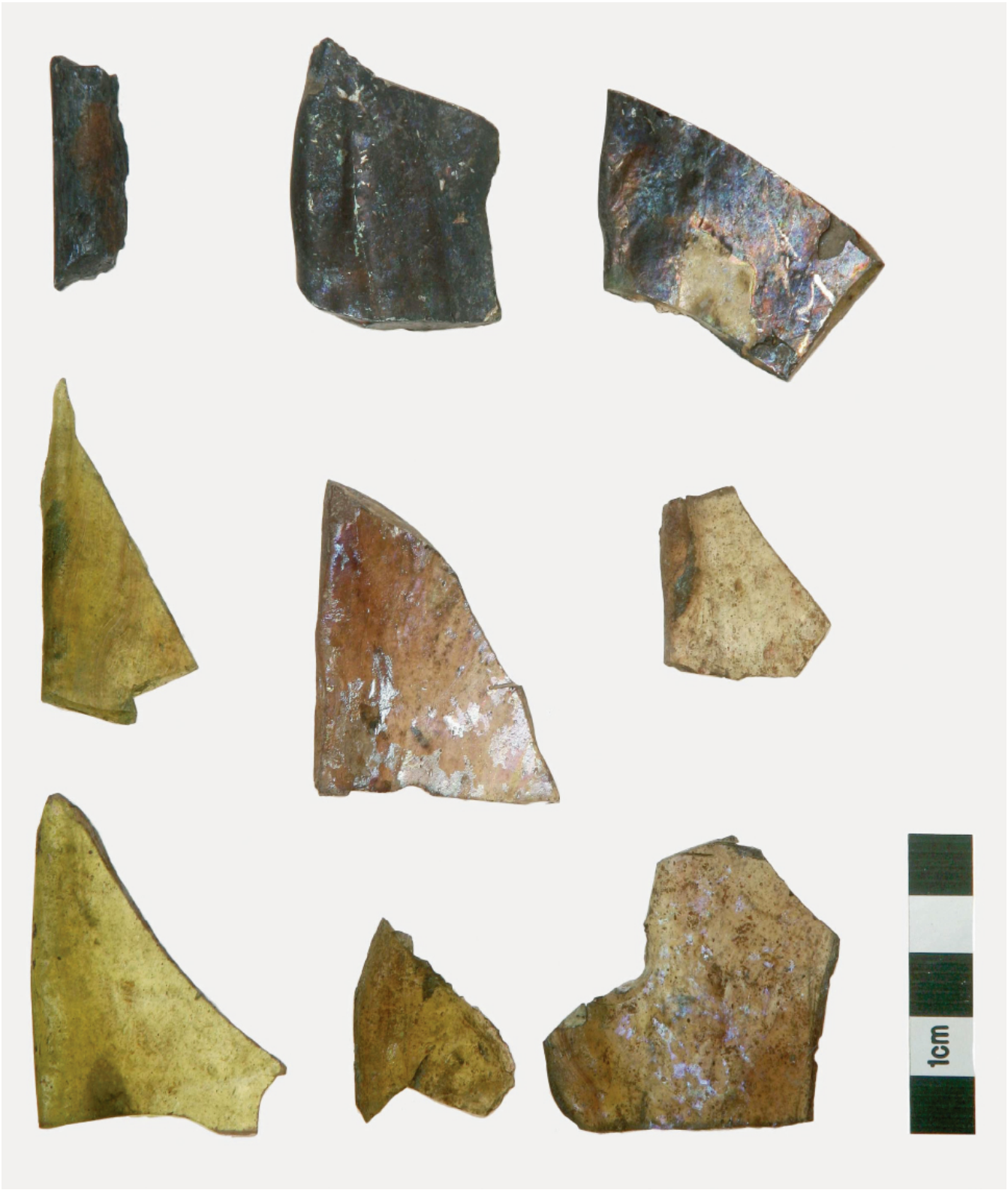

Fig. 14.10: Group 6 early medieval window glass. Photograph J. Barclay-Brown. © The Butrint Foundation.

Another, earlier, type of crown glass had a shallow bowlshaped form. These were domed and had large-diameter splayed, horizontal folded rims and were used for glazing small round openings, particularly in structures with domes (Hayes 1993, 413 and 418, fig. 156 nos 42–3). These round domed panes are very similar in profile to the bowls with folded rims common

throughout the Roman world in the 4th and 5th centuries. Although large-diameter folded-rim sherds from bowls are reasonably common at Butrint none has any trace of mortar adhering to it which was used to secure a domed pane in its circular opening, the usual telltale sign of their function, so it is likely that all these rim fragments are in fact bowls and crown glass was not used in Butrint during the late Roman or early Byzantine period.

Fig. 14.11: Group 4, complete late Antique glass pane from Diaporit. Photograph M. Grayley. © The Butrint Foundation.

Complete flat glass pane

One specific item raises the question whether all the flat glass was in fact used as glazing for windows. A pane of glass, complete but broken in three roughly equal parallel sections, was found during excavations of a villa complex with an adjacent early Christian basilica (possibly a monastic church) at Diaporit, which lies on the eastern shore of Lake Butrint (Fig. 14.1). The maximum dimensions of this Group 4 pane are 33.7cm by 28.9cm, with the shortest side measuring 26.6cm, and despite its sub-rectangular shape the pane is complete (Fig. 14.11). It weighs 667 grams. The top and bottom edges are fire-rounded and the longer sides cut and square in section, the standard configuration for panes of late Antique date; both cut long sides, which are mirror images of each other, have a very slight upward curve along their length. The pane is light yellow-green in colour and the quality of the glass is not particularly good with several large bubbles as well as many small ones. Occasional larger oval bubbles very near the surface slant towards the left on one side below the curving fire-rounded upper edge, but the far more frequent smaller elongated bubbles are parallel to the cut sides over most of the pane. The manufacture of this pane was basically by the cylinder method, but it was obviously further manipulated whilst still soft and before being cracked or split open along its length, as there are distinct indented marks on the surface in a couple of places where one of the short, or top/bottom sides has been pulled to extend its overall length. This has resulted in a wavy edge (Fig. 14.11, bottom edge) and the pulling has obviously narrowed the cylinder at this point as this edge is 2.3cm shorter than the other end which is slightly curved. Trying to extend the cylinder also distorted the alignment of the elongated bubbles in the bottom quarter of the pane from running parallel to the long sides, from top to bottom, to slanting off towards one corner. Although the surfaces are generally smooth this lower section also has a much more irregular outer surface with several distinct runnels running parallel to the edge; the inner surface of the cylinder is shinier than the outer surface which has the typical surface swirls of Group 4 panes. The thickness of this pane is very consistent in the middle area, between 2.7 and 3.0mm, but very variable along the lower edge with the two projecting section being 7.1 and 5.5mm thick while the two corners are only 2.8mm thick. The differences between the two short ends suggests that the glass blowers had problems producing long enough cylinders of the desired size and instead of cutting off all the curving end of the bubble they removed as little as possible, and so had to open up and manipulate one end to extend the length of the cylinder before cracking it open. Evidence from this pane and a number of other fragments indicates that in the late Antique period more than one gather was sometimes used for each cylinder. In these cases there are two layers of glass which have not completely fused together in some areas. This is particularly clear in the dark area in the centre of the complete pane where two layers are clearly visible because fine soil has got between them when the pane was broken at that point (Fig. 14.11).

The pane was found in the apse of a little chapel that lies to the south of the main church and dates between 450 and 500 AD, probably around 490 AD. The apse itself is very small with curving sides and is more like a niche in size. The pane was found in three main sections with a few small fragments in the bottom of the niche, and between the pane and the base of the niche were the corroded remains of three iron nails. Its overall dimensions were only slightly smaller than the bottom of the niche and it seems likely that it was used as a shelf within the niche, either supported on iron nails projecting from the side walls, or in a wooden frame held in place by the iron nails. When the building was abandoned the nails eventually corroded and fell out of the side walls of the niche and the pane fell to its base where it broke.

In the light of this perhaps we need to consider if all flat glass was used for window glazing and look for evidence for other functions. We know from documentary sources that flat panes in portable frames or cloches were used by gardeners providing cucumbers for the emperor Tiberius (r. AD 14–37) (Whitehouse 2001, 31 who summarises the early literature referring to *specularia* (windowpanes) but points out that we cannot tell if these were made from glass or thin translucent stone). Panes of mica and gypsum have been found at Pompeii (Fontaine and Foy 2005, 159–62 and figs 201 and 203), and other sites such as Carthage, but none have so far been identified from Butrint. Even if early panes were made of *lapis specularis* (windowpane stone) it is likely that once flat glass was readily available it soon replaced the stone version.

Summary

Apart from the interpretation of a single complete pane being used as a shelf, how the Roman and early Byzantine flat glass was actually used as window glazing in Butrint can only be a matter of conjecture as there is no direct evidence from either the buildings or the glass itself for this. The primary functions of Roman window glass were to let light into a building and retain heat, particularly in bath houses, and only the very good quality cylinder glass of the late 2nd and 3rd centuries would have enabled the inhabitants of Butrint to see clearly through their windows. No lead items that could be used in conjunction with flat glass have been found, and none of the large quantity of flat fragments so far examined has traces of mortar along the edges, so some other method for securing either individual panes, or groups of panes, in openings must have been used. The most likely explanation is that the panes were set in wooden frames, and this is perfectly possible for the cast and earlier cylinder glass where the panes had regular, straight edges. Mounting some of the later panes, with their far more irregular sides (Figs 14.7 and 14.8), by this method would have been more problematic unless the strips of wood used for the frame were quite wide. The other way glass was secured in openings was by the means of metal grills, but again evidence for these is lacking at Butrint. The evidence suggests that, with very few exceptions, all the Roman cast and cylinder glass was used as plain rectangular panes as there is very little that was either cut into other shapes or had grozed edges. So far only one definite and one possible fragment from the large numbers examined have signs of grozing. Fig. 14.12 shows the definitely grozed fragment with one straight cut side edge with the other edge grozed at an angle with a rounded corner. The other fragment has an apparently more-or-less straight grozed edge, but at right angles to a cut edge. A few pieces have cut side edges that are completely flat and therefore are unlikely to have come from the side of a cylinder. Insufficient numbers of these pieces survive to show if they were cut to trim up a rectangular pane or to cut a larger pane into several smaller panes, or whether they were intended to be another shape.

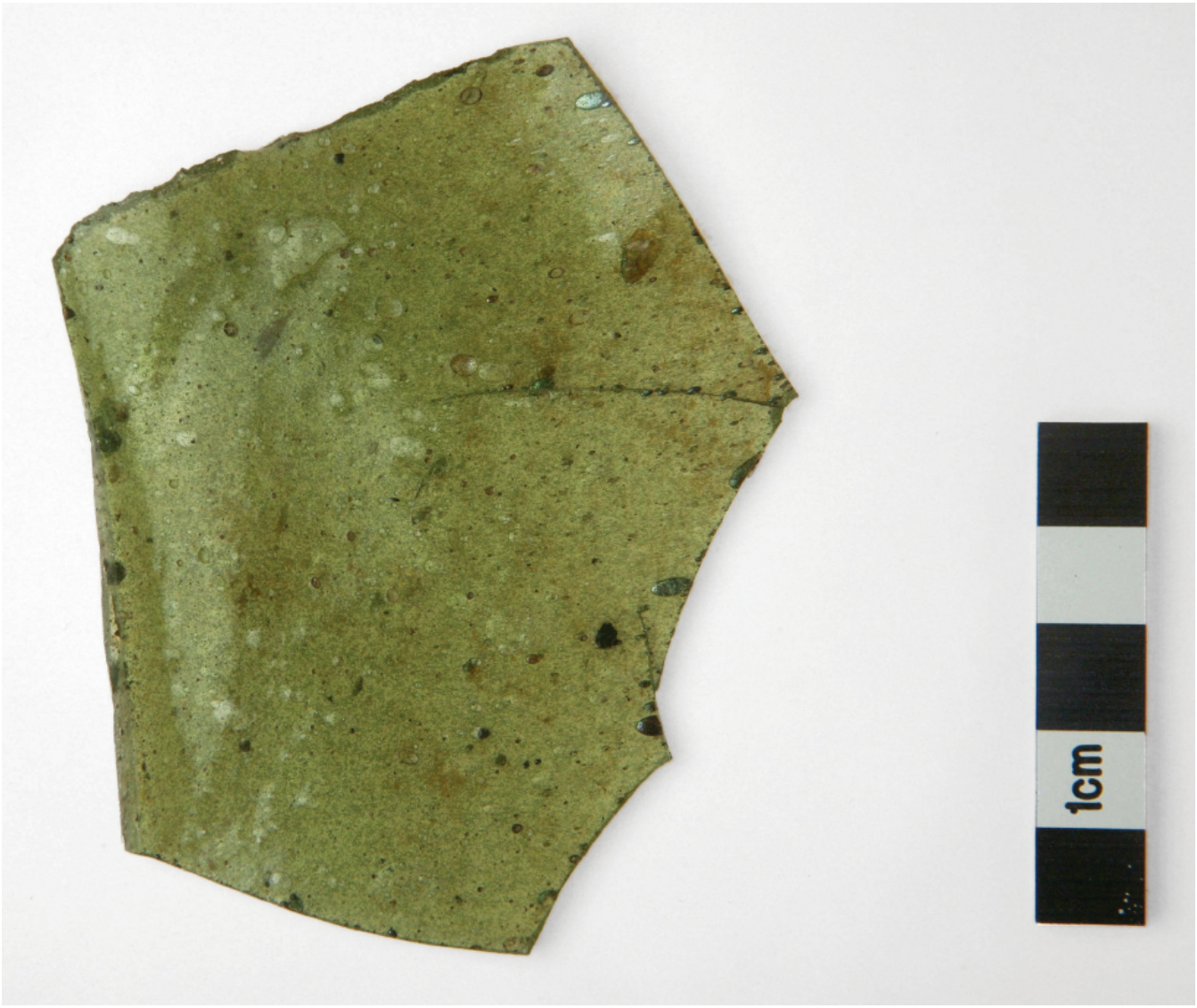

Fig. 14.12. Group 4, cylinder glass, late Antique grozed corner. Photograph J. Barclay-Brown. © The Butrint Foundation.

Where all this flat glass was made, and whether it was produced locally or imported, is also an issue. Although there is good evidence on the Vrina Plain for the manufacture of glass tesserae from cakes of raw glass, to date none of the excavations has produced any evidence for flat or vessel glass working. Butrint, as a major coastal city, was ideally placed to import almost all its needs, but it was also a large enough city to support its own glass working industry and chunks of raw glass have been found in several places. The correlation between the colours and quality of the cast window glass and vessels of the 1st and 2nd centuries is strong, while some of the window glass dating to the 3rd and first half of the 4th centuries appears identical in colour to certain vessel forms, particularly cracked-off rim cups and beakers (Isings 1957, Form 96 and Form 106c), and it is hoped to undertake a programme of analysis to establish if the flat and vessel glass has the same or a very similar composition, indicating a common source for the raw glass used to make both and the likelihood that both flat and vessel glass were made in the same place. By the 5th century, and certainly during the 6th century, there is no apparent relationship between the colours of window and vessel glass suggesting that the two industries were very separate by then. Certainly by that time the

quality of glass used to make flat panes was significantly inferior to that used to produce vessels.

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15

TWO WOODEN GLAZING BARS FOUND IN VINDONISSA (SWITZERLAND) FROM THE COLLECTION OF THE SWISS NATIONAL MUSEUM

Heidi Amrein

This contribution is dedicated to Jennifer Price, who opened many a window for me when I was researching glass dating from Antiquity. Window glass was first used at the beginning of the 1st century AD mainly in public buildings, and in particular in public baths, but also in high-status private residences. In medieval times, window glass was more commonly used in churches and monasteries. Various essays have recently been published on Roman and medieval window glass (Foy and Fontaine 2008; Foy 2005; Dell'Acqua and Silva 2001).

However, this article only indirectly deals with glass, because it presents two window glazing bars made of wood, which came from the famous rubbish dump of the Roman legionary camp at Vindonissa and are today housed in the collection of the Swiss National Museum in Zurich. There are many sites in Switzerland where organic material has been preserved thanks to the humidity of the soil. Important wood and leather finds are known from the small Roman towns (*vici*) of *Vitudurum* (Oberwinterthur, Canton Zurich) and *Tasgetium* (Eschenz, Canton Thurgau), as well as from the Roman legionary camp of *Vindonissa* (Windisch) (Hedinger and Leuzinger 2002). The *colonia* of *Aventicum* (Avenches) is also worth mentioning as, particularly in the areas of the canal and the port, numerous construction timbers and parts of a watermill were preserved (Flutsch *et al*. 2002, 368–369).

The glazing bars

The two wooden artefacts presented here were found together with a rich assemblage of organic and inorganic material in the rubbish dump at the legionary camp of Vindonissa. The earliest excavations were carried out in 1903 and 1906 (Frölich 1906), with later campaigns following in the years between 1944 and 1950 (Speidel 1996, 13–15). In 1911, the Association pro Vindonissa donated two wooden glazing bars, five fragments of cast window panes and a writing tablet to the Swiss National Museum, probably as a way of saying thank you for the conservation work carried out on artefacts from the rubbish dump (Anon 1911, 26).

The rubbish dump at the legionary camp of Vindonissa was located on the northern slope of the River Aare and was associated with the presence of three legions, the 13th legion (c. AD

30-AD 45/46), the 21st legion (AD 45/46-AD 70) and the 11th legion (AD 70-AD 101) (Flutsch *et al*. 2002, 64–67, 401–404). The dump can be divided into two sections; an eastern part, which is dated to *c*. AD 30 to *c*. AD 70, and a later western part, separated by a layer of building rubble and dating from AD 70–101. This rubbish dump reached a volume of approximately 50,000 cubic metres. One may generally assume that all the items from the rubbish dump came from the legionary camp of Vindonissa and were deposited during the period between c.AD 30 and 101. The variety of finds proves that this dump did not only serve certain areas of the legionary camp, but that it was used by everyone (Speidel 1996, 15).

The two pieces of wood were window glazing bars used to partition larger windows (Fig. 15.1). The glass panes of smaller windows were set directly into the mortar (Baatz 1991, 9–11). This is also shown by mortar residue, which is often still visible along the edges of window glass (Billoin and Munier 2005). Various window frames and glazing bars made of wood, stone and metal are known from the Roman period (Foy and Fontaine 2008, 436–439; Baatz 1991, 10–11). For example, a rectangular double window in a wooden frame was preserved in the *Terme Suburbane* of Herculaneum (Baatz 1991, 10–11).

Fig. 15.1: Wooden glazing bars from Vindonissa.

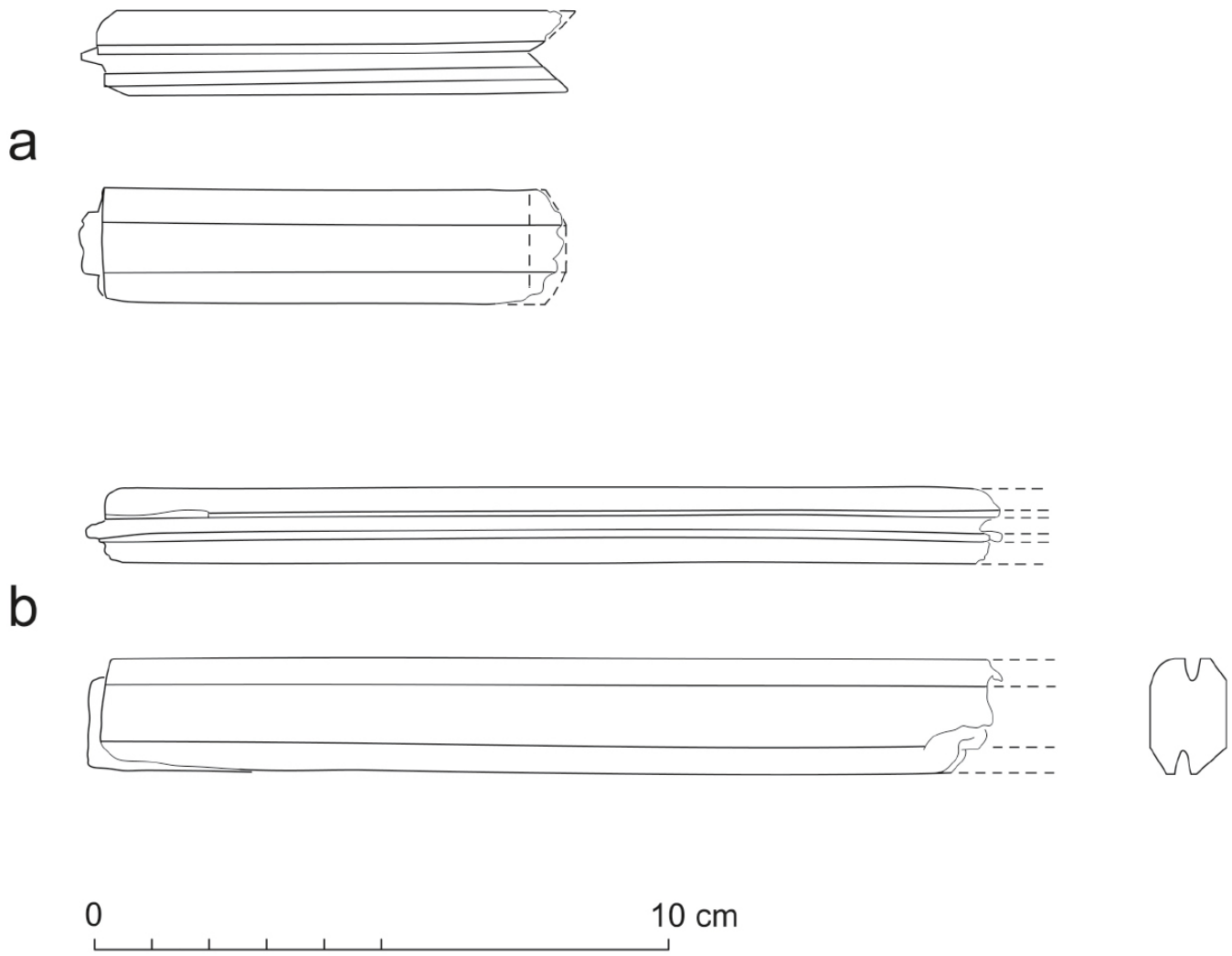
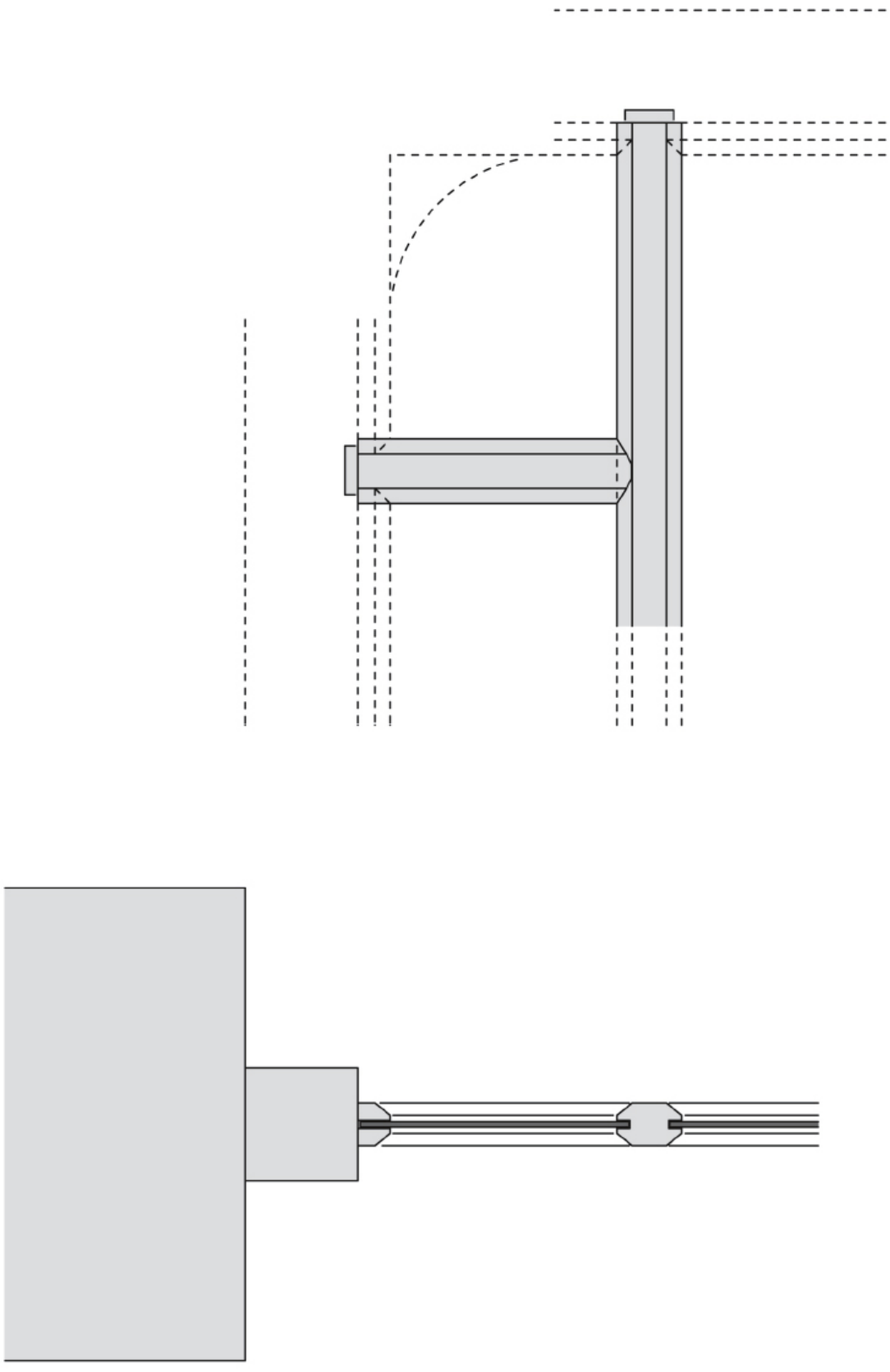


Fig. 15.2: a) horizontal glazing bar, b) vertical glazing bar.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10
20 cm

Fig. 15.3: Assembly of the horizontal and vertical bars with tenon and bird's-mouth notch.

The two glazing bars from Vindonissa are 21mm wide and have grooves on both their long edges which held the glass panes in place (Fig. 15.2). The surfaces of the bars are slightly cambered and ribbed longitudinally. Due to drying out, the artefacts are probably slightly smaller today than they were originally. Item 'a' terminates at one end in a rectangular-shouldered tenon. The opposite end has a triangular notch, a so-called bird's-mouth. The length of the glazing bar (including the tenon) measures 85mm. Only one end of glazing bar 'b' has been preserved. Like artefact 'a', it also has a rectangular-shouldered tenon. It survives to a length of 160mm; its original length is unknown. Tenon, bird's-mouth and mortice joints are among the most common elements of joinery found on Roman construction timbers (Pauli-Gabi *et al*. 2002, 150–151).

The two glazing bars are not unusual artefacts among the finds from Vindonissa. Over 150 identically-shaped glazing bars have been identified in the collection of the Vindonissa Museum (Fellmann 2009). All the fragments, including the two artefacts dealt with here, were made from the same type of wood, namely silver fir (*abies alba;* R. Fellmann, Vindonissa Museum, personal communication). It is a light and resin-free timber, easy to split and highly workable; it was used in construction and also to manufacture writing tablets, stoppers and barrels and other containers for liquids (Hedinger and Leuzinger 2002, 152). Silver fir was also widely used in southern Italy, for example in the manufacture of furniture (Mols 1999, 75–76). In addition, Pliny reports that silver fir was mainly suited for interior woodwork and the construction of doors (Pliny the Elder, *Historia Naturalis*, 16.225).

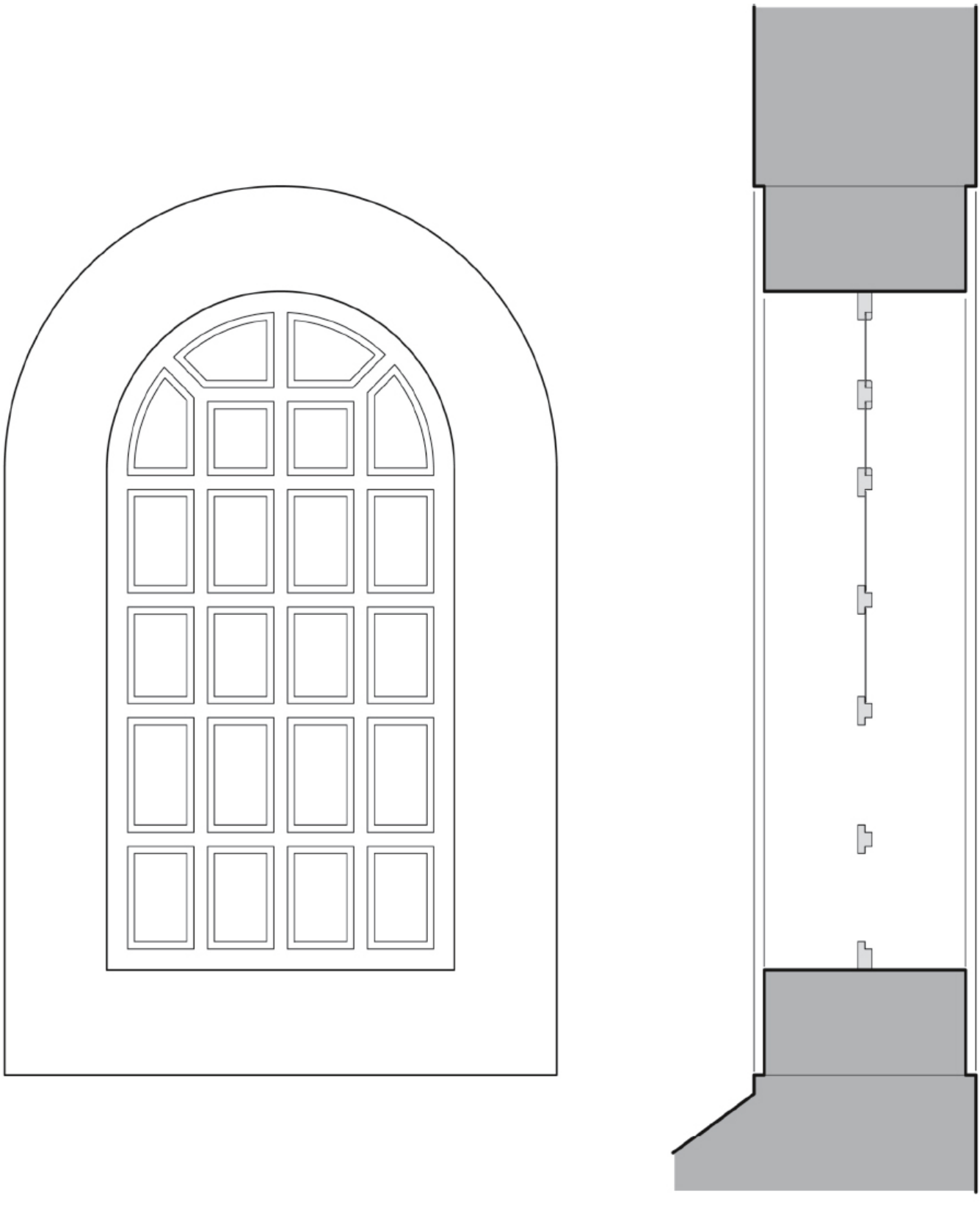
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Fig. 15.4: Reconstruction of the round-headed window from Ravenna with wooden frame and glazing bars.

The two glazing bars from Vindonissa do not readily lend themselves to a reconstruction as they were not found in their original context but in a rubbish dump, and are highly unlikely to have originated from the same window. The schematic reconstruction (Fig. 15.3) is intended to show the joints, and the construction of a window from which they potentially could have come. The shorter fragment was a horizontal cross bar, which was fitted onto a vertical bar by means of the bird's-mouth notch. The height of the window pane is based purely on hypothesis, as artefact 'b' is not preserved in its entirety. The width of the glass pane, however, is known and measured approximately 70mm, which is very small compared to at least some complete rectangular Roman glass panes (Fontaine and Foy 2005, 23). This might be explained by the theory that the horizontal fragment 'a' came from the upper section of a round-headed window or from a circular window, where the cross-bars would have been much shorter and the glass panes would have been cut to fit. A Roman wall painting from Bavay probably shows a circular window with rectangular sections and cross bars quite clearly of different lengths (Eristov and Groetembril 2005). An interesting example of a window with a wooden frame and glazing bars and with an arched top was found at the *Julianus Argentarius* Basilica near Ravenna. Restoration work undertaken in 1899 and 1900 revealed two window frames with glazing bars, which, apart from the rounded section at the top, were fitted with rectangular glass panes. It remains unclear whether these windows date from late Antiquity or from the early Middle Ages (Deichmann 1958, 239–240, figs 116–117; Fig. 15.4).

I would like to add here that I had originally considered an interpretation that these two wooden pieces were used as divisions in wooden panelling or in large pieces of furniture. However, I was unable to find convincing parallels to support this.

Discussion

I would like to add some remarks regarding the significance of the wooden glazing bars in terms of cultural history. One may raise the question whether such glazing bars were widely known, and whether they were typically used in certain buildings or types of settlement. These questions cannot be answered definitively but the current state of research sheds some light on them. A comparison with other Swiss sites which have yielded many timber finds resulted in an interesting observation. Not a single fragment of a window glazing bar has been identified in provincial towns such as Eschenz or Oberwinterthur (Hedinger and Leuzinger 2002 and personal communication). As far as I am aware, in the provinces north of the Alps, only two military settlements have so far yielded wooden glazing bars, namely the legionary camp of Vindonissa with more than 150 bars (c. AD 30–101) and the fort of Saalburg with one example dating from the early 2nd century AD, which was also made of silver fir (Baatz 1991, 10, pl. 5b; Klee 1995, 75).

In Vindonissa, a Mediterranean influence manifested itself in various aspects of life, which was probably associated with the presence of high-ranking military personnel. The analyses carried out on both the animal bones and the archaeobotanical remains suggested the presence of southern imports, for instance pomegranates, and pointed towards a Mediterranean influence in the diet, which is not detectable in other Roman settlements in what is now Switzerland (Flutsch *et al*. 2002, 401). Some of the buildings in Vindonissa were also clearly influenced by Mediterranean architecture, such as the palatial *praetorium*, the residences of the high-ranking officers (Meyer-Freuler 1998, 62–64). It is, indeed, possible

that the glazing bars from Vindonissa all came from the same building. This raises the question whether windows partitioned by wooden bars were typical of Mediterranean architecture. The Herculaneum finds mentioned above may support this theory. In timber construction such as that found in the Roman north-west, for instance in Eschenz, Oberwinterthur and on the Auerberg, this type of window was obviously not commonly used.

In my opinion this raises the question whether window glass was widely used throughout the Roman Empire. The climatic conditions north of the Alps required the windows to be closable. This could also have been achieved with wooden shutters. Light openings in the timber buildings of provincial towns were probably provided mainly by open fronts and gable ends of the buildings (Pauli-Gabi *et al*. 2002, 127–128; Weber 1996, 136–137). One may also ask how widespread the use of so-called windowpane stone (*lapis specularis*) was (Foy 2007)? This was a kind of transparent gypsum, which was split into panes and was mined in *Segobriga* in Spain during the Roman period. A find made at the Villa *Les Bossenno* in Carnac seems to provide evidence that iron and lead were used to make fittings for glass panes (Vanpeene 2005). As regards further research into windows dating from Antiquity, besides the systematic recording and analysis of the find contexts of window glass, it would be interesting to search for potential evidence of fittings and window frames.

Acknowledgements

I am very grateful to Regine Fellmann for facilitating my access to the glazing bars in the Vindonissa Museum. Fig. 15.1 is by Donat Stuppan, Swiss National Museum. Figs 15.2–4 are drawn by Daniel Studer; Fig. 15.4 is based on Deichmann 1958, figs 116–117. The translation is by Sandy Haemmerle.

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16

THE RE-USE OF ROMAN GLASS FRAGMENTS

Sylvia Fünfschilling

Introduction

Lately, while studying various finds assemblages, individual glass sherds and bases caught my eye, which appeared to have been re-worked after they had been broken; this reworking must have served a particular purpose. Re-worked glass sherds are known from all over the Roman Empire and several examples have, indeed, been published. However, as far as I am aware, detailed analyses or studies of the various types of re-working have not yet been undertaken. In Augst, no attention had been paid to this phenomenon (Rütti 1991). This led me to initiate a search of the finds discovered between 1981 and 1992 which were stored in the museum of *Augusta Raurica*, resulting in the discovery of a significant number of potentially re-worked artefacts. Despite the fact that excavations had been carried out within the Roman fort between 1981 and 1992, none of the 4th-century AD features had yielded any re-worked sherds. At this point in time, the relevance of this fact cannot be fully assessed.

Vessel sherds

Base sherds were found to have been re-worked, while sherds of vessels were also re-used. The latter could have one or several grozed edges and could even be fashioned like a Stone Age flake. There were also artefacts which were re-worked into regular shapes.

Most of the bases had footrings. They were either the usual folded tubular base rings or disc-like folded bases (for example Isings form 109) and closed vessel shapes, or applied base rings like those of Isings form 85. The upright remnants of the vessel walls tended to have been trimmed neatly (Figs 16.1 and 16.2). Of course, small spikes were still present but, as mentioned, they were small and on vessels with thicker walls, the working traces left by the smoothing of the breaks were obvious. The removal of the vessel walls was usually executed by neatly following the curvature of the footring, and nothing was left protruding beyond it.

One may assume that these bases were re-used as lids. As a lid, the object can easily be gripped by the footring while the trimmed break is on the inside of the vessel where it is out of the way. On the other hand, one could also hold the lid by the trimmed wall with the footring providing further grip. Of course, the type of vessel covered by these lids can only be determined if clear finds associations can be identified. Very convincing results were achieved in an experiment where the re-worked glass bases were placed in the openings of ceramic

jugs and beakers. On the other hand, the re-worked bases could alternatively have been used as small bowls.

This phenomenon of trimming vessel wall remnants can also be seen in pottery, particularly in the case of footrings of larger Samian ware plates. Here again, the walls were neatly trimmed along the footrings. There are also body sherds from various types of pottery which were worked into large round discs which could have been used as lids, for instance. Small round discs made from pottery and glass sherds were probably sometimes used as gaming counters.

During the search through the glass collection, a total of 16 re-worked glass bases were discovered, despite the fact that only the finds recovered in the years 1981–1992 were examined. Quite a few of them were intact, some were broken exactly down the middle and the others were fragmented. It is worth noting that almost all of them came from contexts dating from the late period of the *colonia*, that is from about 200 to the mid 3rd century. A small number, among them the foot of a beaker of Isings form 109, dated from later times, while a few dated from an earlier period. Most of them were recovered from rubble layers and levelled areas, some of which were located directly below the topsoil. In the case of Augst, therefore, a more detailed study of the structures is not required in order to state that the finds were from the late phase of the town.

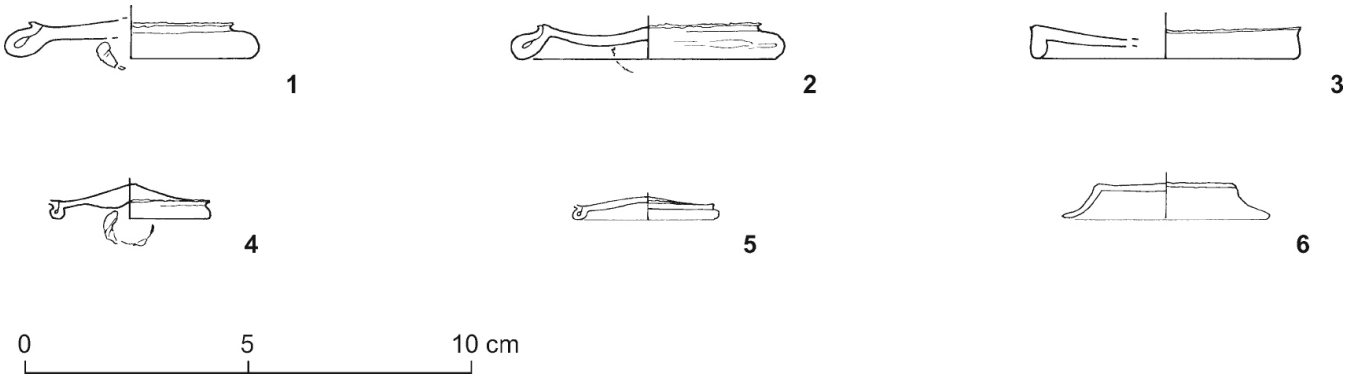

Fig. 16.1: Re-worked bases from Augusta Raurica.

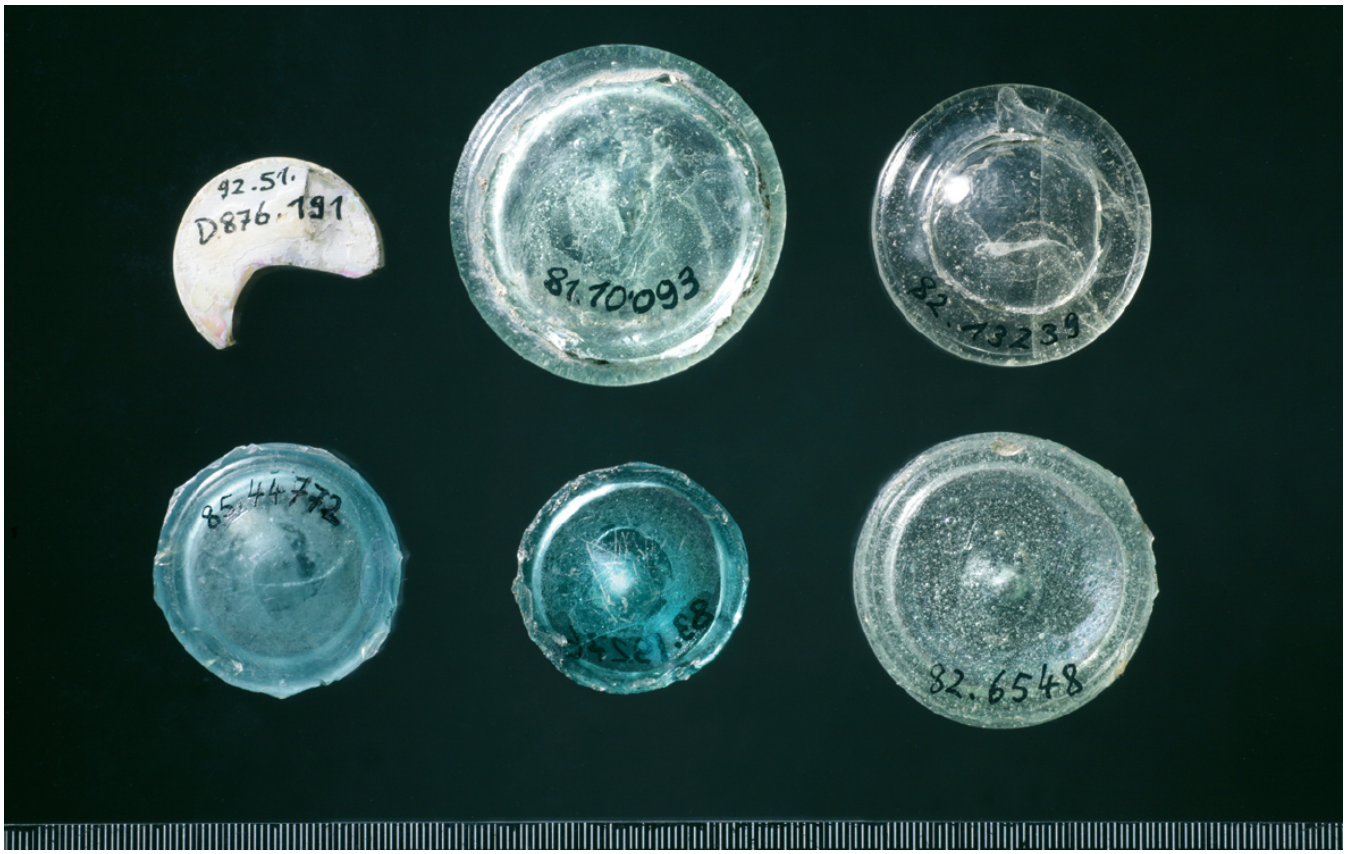

Fig. 16.2: Re-worked bases from Augusta Raurica. Scale in mms.

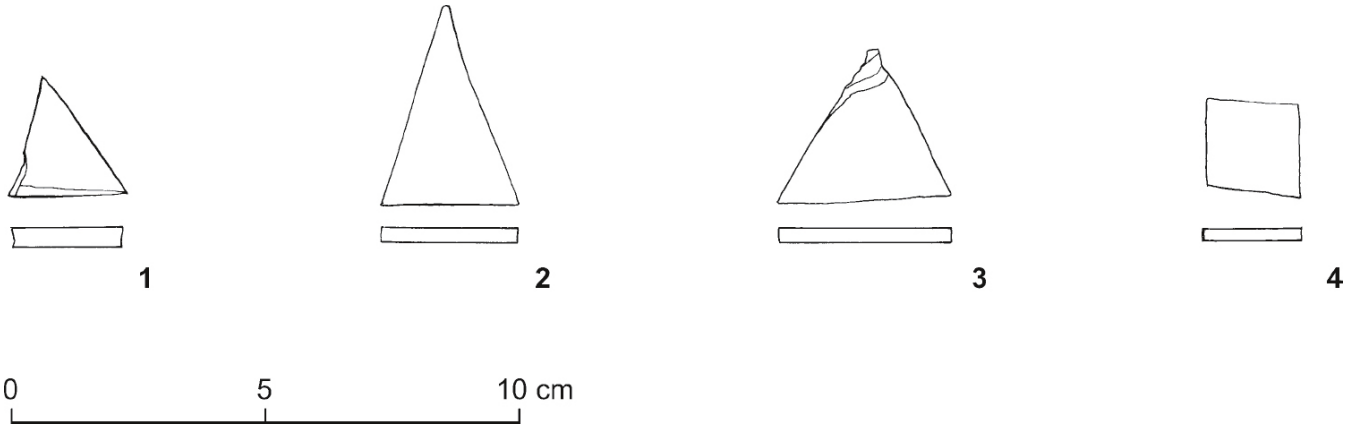

Fig. 16.3; Sherds broken in geometrical form. Augusta Raurica.

Flat sherds

Besides the lids and/or bowls, flat sherds are repeatedly found, which are either broken into completely regular forms (Figs 16.3 and 16.4) or whose breaks exhibit characteristics resembling prehistoric lithic tools (Figs 16.5 and 16.6). Some sherds even look exactly the same as Stone Age flake tools (Figs 16.7 and 16.8). The breaks of the geometrically shaped sherds are also sometimes reworked (Fig. 16.5, 16.3). If this was not the case, one could presume that the sherd coincidentally broke in this shape. Particularly in the case of window glass some of the fracture patterns are very unusual (Figs 16.9 and 16.10). However, I am not convinced that shapes such as triangles, rectangles and squares always occurred by chance.

What these small geometric glass fragments were used for as yet remains unknown to us. They may have been used in inlay work, but hardly any pieces of furniture or small chests have been preserved in this region, and upstanding masonry is also rarely found. Four small square objects with re-worked edges, possibly part of a piece of jewellery, were recovered from a burial in Saintes (Chew 1988, pl. 4, 39). Diadem inlay made of bronze-trimmed glass sherds was found in children's burials in Hungary (Fülep 1984, fig. 99, grave 10, no. 7). In the west, such finds occur more rarely, but have been found, for example, in Mayen (Haberey 1942, 275) and in Belgium (Mariën 1994, 54, fig. 23, 14). It is hard to decide whether regularly fragmented glass was also re-used (Figs 16.9 and 16.10). After all, concentrations of such fragments are occasionally found in contexts which are not obviously linked with glass recycling by re-melting.

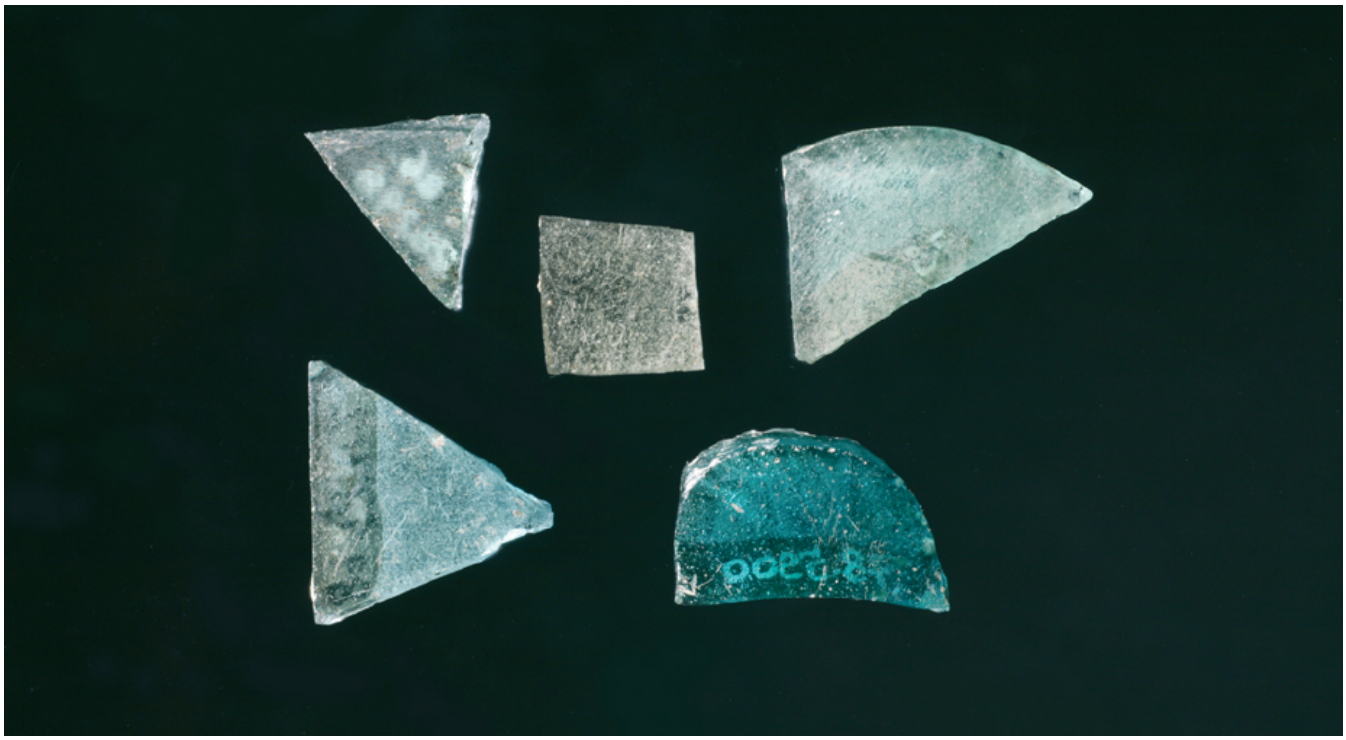

Fig. 16.4: Sherds broken in geometrical form. Augusta Raurica. Scale in mms.

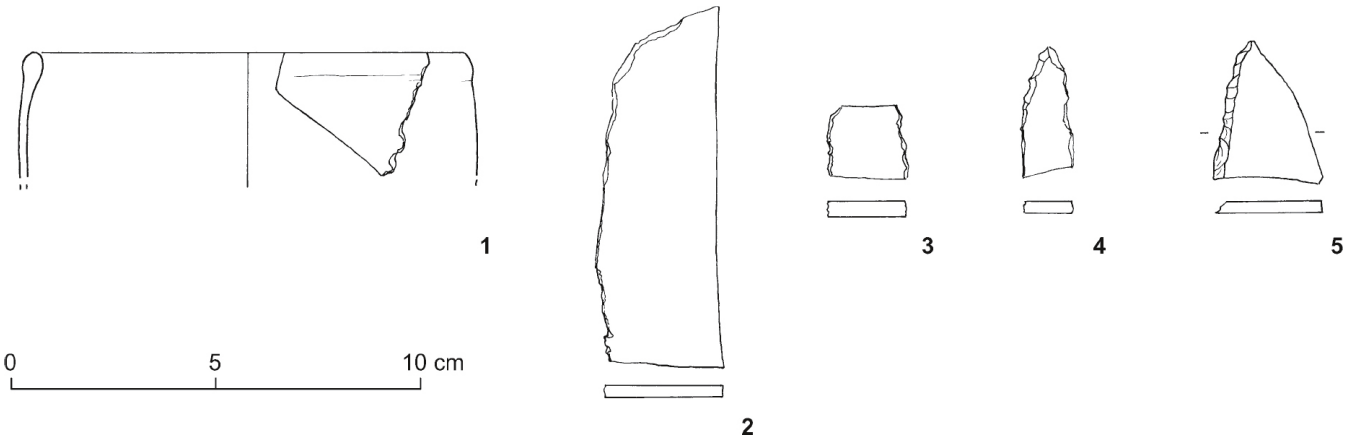

Fig. 16.5: Vessel fragments with re-worked edges. Augusta Raurica.

Fig. 16.6: Vessel fragments with re-worked edges. Augusta Raurica. Scale in mms.

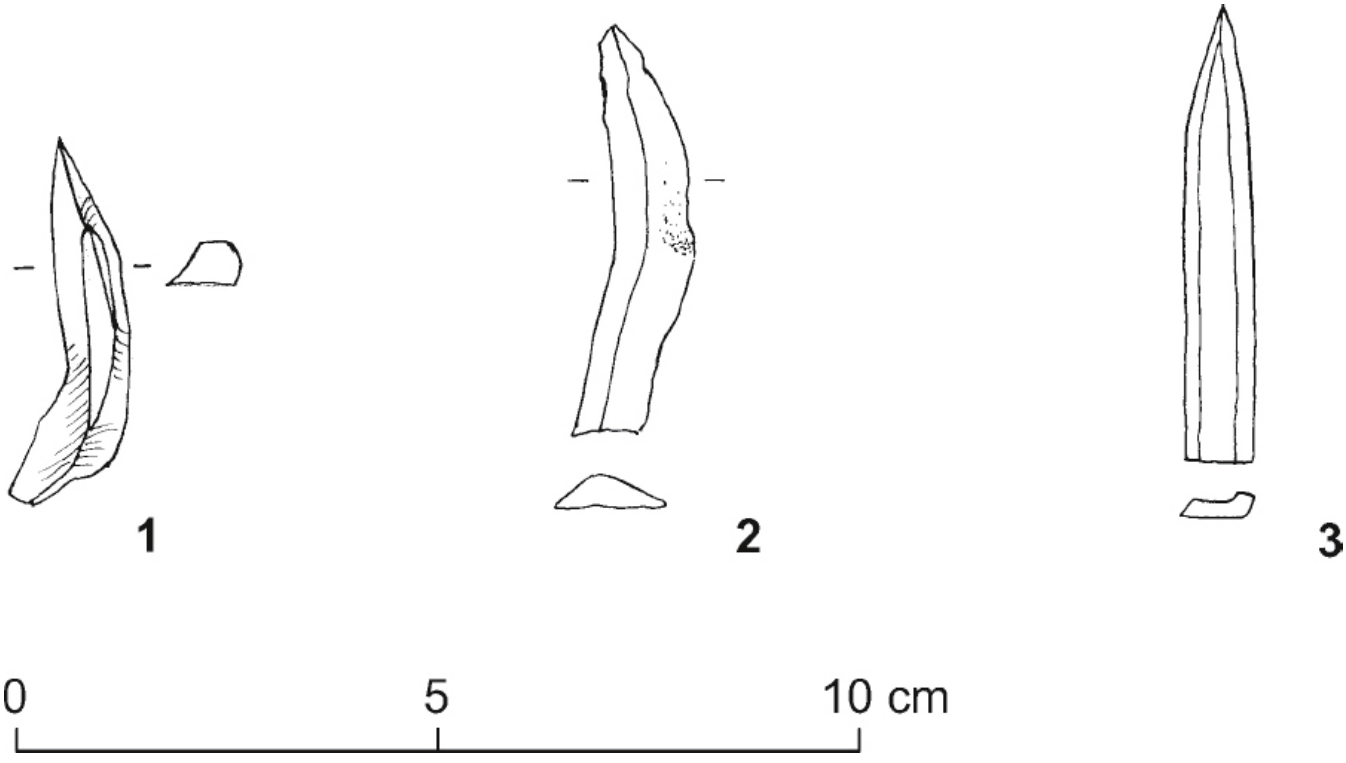

Fig. 16.7: Vessel fragments worked like flint (no. 1–2) and a gouge (no. 3).

Fig. 16.8: Vessel fragments worked like flint and a gouge. Scale in mms.

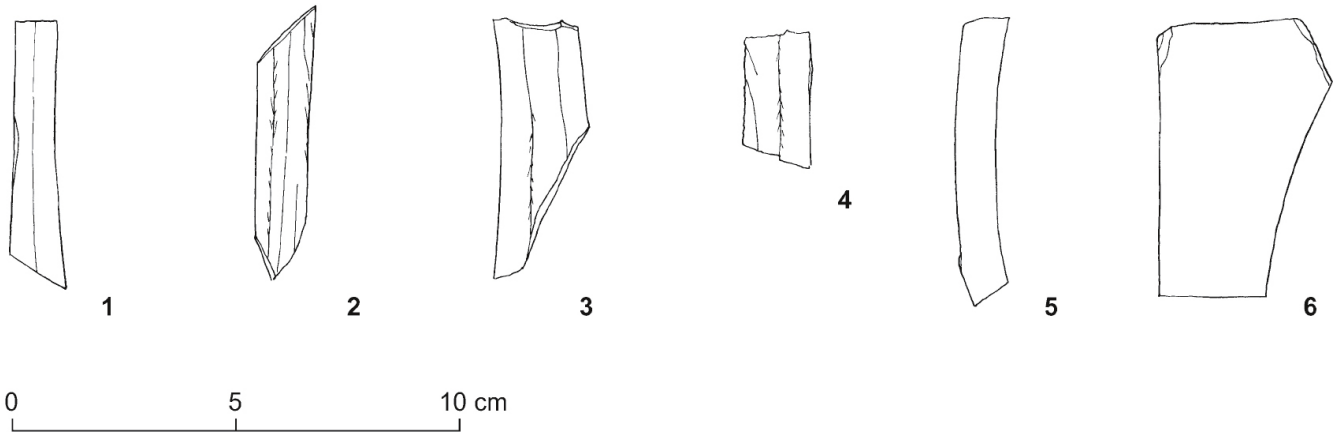

Fig. 16.9: Window glass broken in geometrical form. Augusta Raurica.

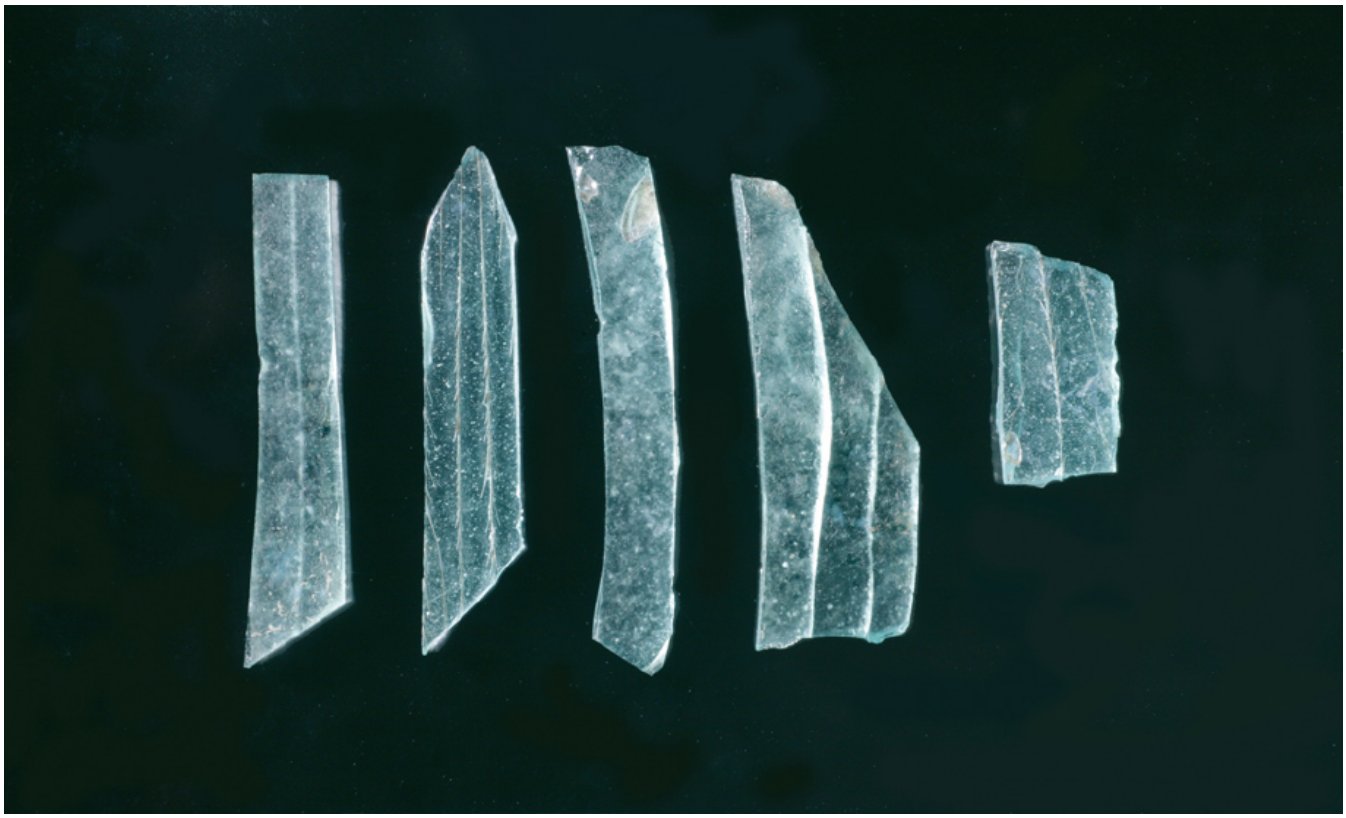

Fig. 16.10: Window glass broken in geometrical form. Augusta Raurica. Scale in mms.

There are also sherds on which one or, more rarely, several breaks are re-worked to achieve a kind of cutting edge (Figs 16.5 and 16.6). One may argue that a cutting edge should be straight and smooth like that of a knife, but these grozed edges seem to have been used for a specific purpose. They may even have been hafted with a material long since decayed.

I remember seeing an image in a publication – the reference to which unfortunately escapes me – which depicted a potter with such a glass sherd. It is difficult to say what exactly such a glass sherd can be used for in making pottery; the application of decoration is a possibility, however no locally produced pottery with impressed decoration dating from the late period has been found in this region. The 3rd-century cooking pots with horizontal grooves are more likely to have been decorated using a comb-like tool made of wood, bone or some other organic material. Given that the grooves were quite jagged, it cannot be entirely excluded that they were made with a glass sherd that was re-worked as described above.

It seems more likely that these tools were used in many other crafts that we are no longer familiar with today, perhaps mainly in the area of textile, leather and fur manufacture, and possibly also in plaiting and basket weaving. Seemingly, shoemakers in the Orient used to polish leather shoes with similar glass sherds well into modern times (Miller 1984).

A fragment from Augst, which came from a jug (Isings form 50), was shaped into a point, which could be used as a gouge to work soft materials (Fig. 16.7, 3).

Re-worked glass from Augst

When studying the distribution of the re-used bases and the other re-worked sherds, concentrations can be identified in some particular excavations: in the area called Schmidmatt, at Kastelen, in Insula 35 and Insula 50 (Fig. 16.11). An industrial building with a fulling mill

stood on the Schmidmatt site, and at Kastelen there was a rich urban villa and, in the late period, a fortification pre-dating the fort. Insula 35 was a craftsmen's quarter as was Insula 50. Several finds from the 'Frey excavation', a roadside development at the eastern edge of the town with early potters' kilns and a later house with baths, came from structural contexts that did not provide much information.

Unfortunately, it was not possible to link the grozed fragments from Augst with a particular craft. A search of the finds recovered from the areas of the town with potters' kilns produced a negative result. While crafts have been identified in some of the *insulae*, no direct connection could be made. Insula 50, for instance, was the location of a counterfeiter's workshop, textile production could be identified on the Schmidmatt site, and two re-worked fragments came from the vicinity of the glass kilns in the Unterstadt area. Insula 35 also yielded various traces of craft activities, but actual workshops could not be identified. Within the area of the 'Frey AG excavation' where, among other things, early potters' kilns were found, the re-used sherds came to light in completely different areas, mainly in the vicinity of the baths. However, it is highly unlikely that they had any connection with them.

The tools and regular sherds appeared in the Augst area from Flavian times onwards and occurred time and again throughout the main settlement period.

The re-worked glass sherds can only be identified among the other finds by detailed observation and if the finds are in a good enough state of preservation. In the case of the window panes that were shattered into geometric shapes (Figs 16.9 and 16.10), one must raise the question of whether these breaks can also occur naturally. Sometimes one can make out regular grooves in the window panes which are probably signs of weathering. Of course, the sherds are likely to break along these grooves. However, it remains unclear whether deliberate use was made of the way in which window glass shatters in order to re-use the sherds, or whether window glass was manipulated so that it would break into regularly-shaped fragments.

Other finds of re-worked glass

Other sites in what is now Switzerland have also yielded similar finds:

- A sherd fashioned in the shape of a flake from the Roman villa in Biberist was found in layers dating to the first half of the 3rd century. It was discovered in stone building J, which yielded glass vessels that were used mainly for transporting and storing goods (Fünfschilling 2007, 124, fig. 15/19.2).
- The Early Imperial layers of the legionary camp at Vindonissa also yielded re-worked sherds and a fragment of a balsamarium, which is broken into a ring shape and whose breaks are rounded; both came from the timber construction period 7, which is dated to *c.* AD 40–45/47. (Fünfschilling 2003a, pl. 44, Gl105 and Gl131).
- Other re-worked sherds came from Lausen, an early medieval settlement near Augst, which succeeded a Roman villa rustica. There a base sherd was found which was knapped into a round shape; two folded rim fragments had been re-used as beads (unpublished).
- In the Late Antique castrum of Pfyn, the neck of a vessel was smoothed so the vessel could continue to be used. Furthermore, an oval base ring was re-used and a small base was perforated in secondary use (Fünfschilling 2003b, pl. 62, 3266; pl. 52, 2848; pl. 64, 3286).
- The phenomenon of trimmed down and re-used bases occurred throughout the Roman Empire, for instance in Horvat Raqit in Israel (Jacobson 2004, 253 Photo A, 2), where they were also found in late contexts, and in Nicopolis ad Istrum (Shepherd 1999, 353, fig.

11.17,667.668). They are also found in France, several re-worked sherds and trimmed down bases came from the settlement of Châteaubleau near Paris (Fünfschilling 2008, pl. 5, 210 Châteaubleau/Theâtre; pl. 10, 41 Châteaubleau/L'Aumône; pl. 18, 233–235 Châteaubleau/Les grands Jardins; pl. 20, 55 établissement rural Vieux-Champagne/Le Bois du Châtel), in the Germanic region, and in Great Britain (e.g. Cool and Price 1995). It is also worth mentioning a base found as a grave offering in the burial of a Langobardic woman in Nocera Umbra, where it was deposited beside the head of the deceased (Rupp 1996, 99, fig. 15); the phenomenon continued into the early Middle Ages.

- The re-worked sherds are somewhat more difficult to assess, probably because they have not been paid proper attention. However, they have been found in Syria where sites have yielded both glass fragments that were knapped like Palaeolithic tools and pottery sherds, as well as numerous flint tools (Kehrberg 1992). These were used in the Late Roman and Byzantine periods. In Belgium several examples came to light in the craftsmen's settlement of Liberchies, but again they could not be linked directly with a particular craft. Colchester too has yielded quite a number of re-worked sherds (Cool and Price 1995).

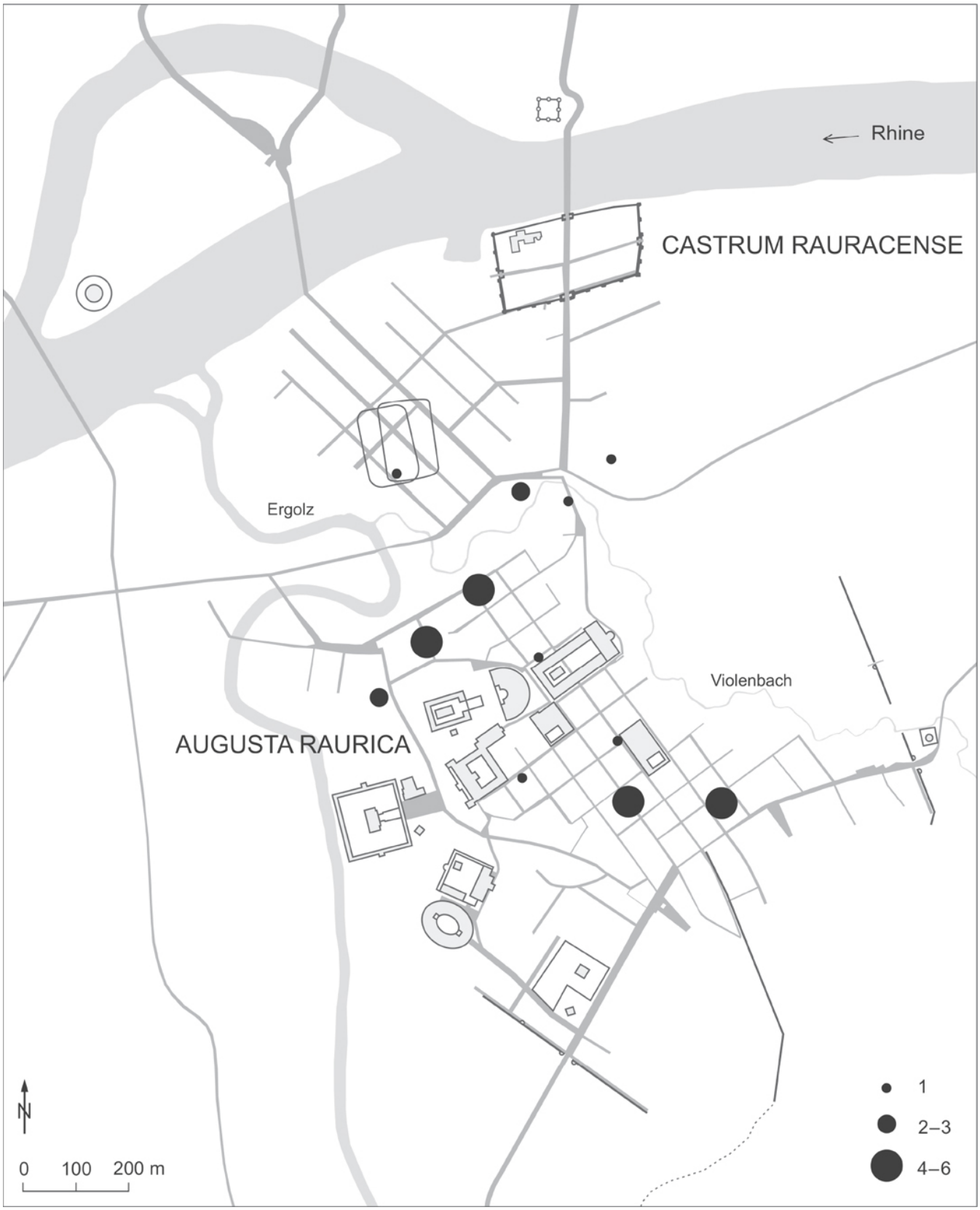

Fig. 16.11 Plan of Augusta Raurica showing find spots of re-worked glass objects.

Acknowledgements

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17

ROMAN ENAMELS AND ENAMELLING

Justine Bayley

Introduction

Roman glass has long been Jenny's main passion. Her knowledge of it is encyclopaedic so, although she has encouraged others to share her enthusiasm, it is difficult to find areas where our knowledge can begin to rival hers. One of those rare topics is enamelling – the subject of this paper.

Enamel is glass that is fused to another material, usually metal, though some Roman glass vessels were also enamelled (Rütti 1991; Price and Cottam 1998, 33–4). Although many types of enamelling on metal are known in medieval Europe (*e.g*. Campbell 1983, 6–7), all Roman examples used the champlevé technique: coloured glass, normally opaque, fused into sunken fields cast or cut into the metal. Champlevé enamelling is also found in the later pre-Roman Iron Age (Stead 1985, 14), and should be seen as a native decorative technique that was adopted and developed by the craftsmen working for a Romanised market. Enamel is rarely seen on high class objects, or in the Mediterranean parts of the Roman Empire, but was widely used in the North-Western Provinces and Pannonia.

Britain was famous for its enamelwork, as Philostratus noted in the early 3rd century AD: 'they say that the barbarians that live in the Ocean pour colours onto heated bronze and that they adhere, and grow hard as stone, keeping the designs that are made in them' (Fairbanks 1979). Archaeological work in England has confirmed the old assumptions that enamelled objects were made in the Roman province of Britannia (*e.g*. Künzl 1995); the discoveries include decorated moulds for casting metal objects with sunken fields to take enamel, and raw enamel that would have been used to decorate them.

Types of objects that were enamelled

Enamel was widely used to decorate a range of everyday objects. Bateson (1981) provided a survey of British finds, mainly jewellery and personal trinkets. Since then many more enamelled objects have been found in the course of excavations and, more recently, reported to the Portable Antiquities Scheme (http://www.finds.org.uk). Typical objects are brooches (e.g. Bayley and Butcher 2004; 17% of those studied were enamelled), button and loop fasteners, studs, seal boxes, votive stands, bath-oil flasks and paterae (e.g. Breeze 2012). Small numbers of other object types such as belt plates, finger rings and pins are also occasionally enamelled.

Types of enamel decoration

The enamel fills hollows, known as fields, cast or cut into the metal. The most frequent style is simple enamelling, with one colour in each small field, though several colours may be present in different fields on a single object (Fig. 17.1). Simple enamelling was sometimes combined with reserved copper alloy spots in the fields (e.g. Bayley and Butcher 2004, fig. 100, no 384), tinning of the surrounding metal (e.g. Bayley and Butcher 2004, plate 13), or soldered-on silver wire or foils (e.g. Bayley and Butcher 2004, plate 8).

Larger enamel fields, particularly on plate brooches, can sometimes hold simple enamel but often they contained more than one colour. These complex enamels show a variety of techniques including juxtaposed blocks or areas of alternating colours, millefiori, inserted spots, either monochrome or with concentric circles of more than one colour, and mixed polychrome or marbled enamel.

Fig. 17.1: Fields of opaque turquoise and orange enamel on a bow brooch; length 34mm (NN124). Figs 17.1–17.11 all show enamels from Nornour.

Fig. 17.2: Juxtaposed blocks of two colours of enamel on bow brooch; length 47mm (NN 312).

Fig. 17.3: Irregular juxtaposed areas of red, white and blue enamel on a plate brooch; enamel field 16mm long (NN 236).

Fig. 17.4: Red-bordered 5x5 blue and white chequerboards alternate with red and blue florets on a white ground. The millefiori blocks are too small for the annular field so a brighter red enamel fills the gap; image width 19mm (NN 205).

Romano-British craftsmen used only simple enamelling and, less commonly, juxtaposed blocks of enamel. These techniques were also used by Continental craftsmen who additionally used all the other types of complex enamelling.

Juxtaposed blocks of enamel of two (or sometimes more) alternating colours could fill a field. Usually it appears that blocks of glass were cut and fused into place as the dividing lines between them are very straight and sharp (Fig. 17.2). In other cases the divisions are still sharp, but are not so straight (Fig. 17.3), suggesting either the blocks became very soft and distorted, or that adjacent areas of powdered enamel of different colours were applied. The rarely-found two-colour enamelling, where a single field is split between two colours, could be considered a simplified version of this latter variant of juxtaposed enamel, but the types of brooches on which it is found suggest it is best considered as a variant of simple enamelling.

Millefiori is the name now used to describe small polychrome patterns in glass. These are made by arranging glass rods of various colours side by side, heating them just enough to fuse them and stretching the bundle of rods into a long thin cane. When cold, patterned slices can be cut from the cane and used as part of enamelled designs. The slices of millefiori canes could be used on their own (Fig. 17.4), alternating with blocks of plain colours, or set

randomly into a field of a single colour of enamel (Fig. 17.5). Mosaic glass vessels (Freestone and Stapleton this volume) were made in a similar way, by arranging slices from the cane side by side and heating them sufficiently to fuse them before slumping the resulting disc over a former to produce a 'cast' glass vessel (Taylor and Hill 2003). The canes used to make vessels are usually larger in diameter and have rather different patterns to those used for enamelling (e.g. Price and Cottam 1998, pl. 1.3).

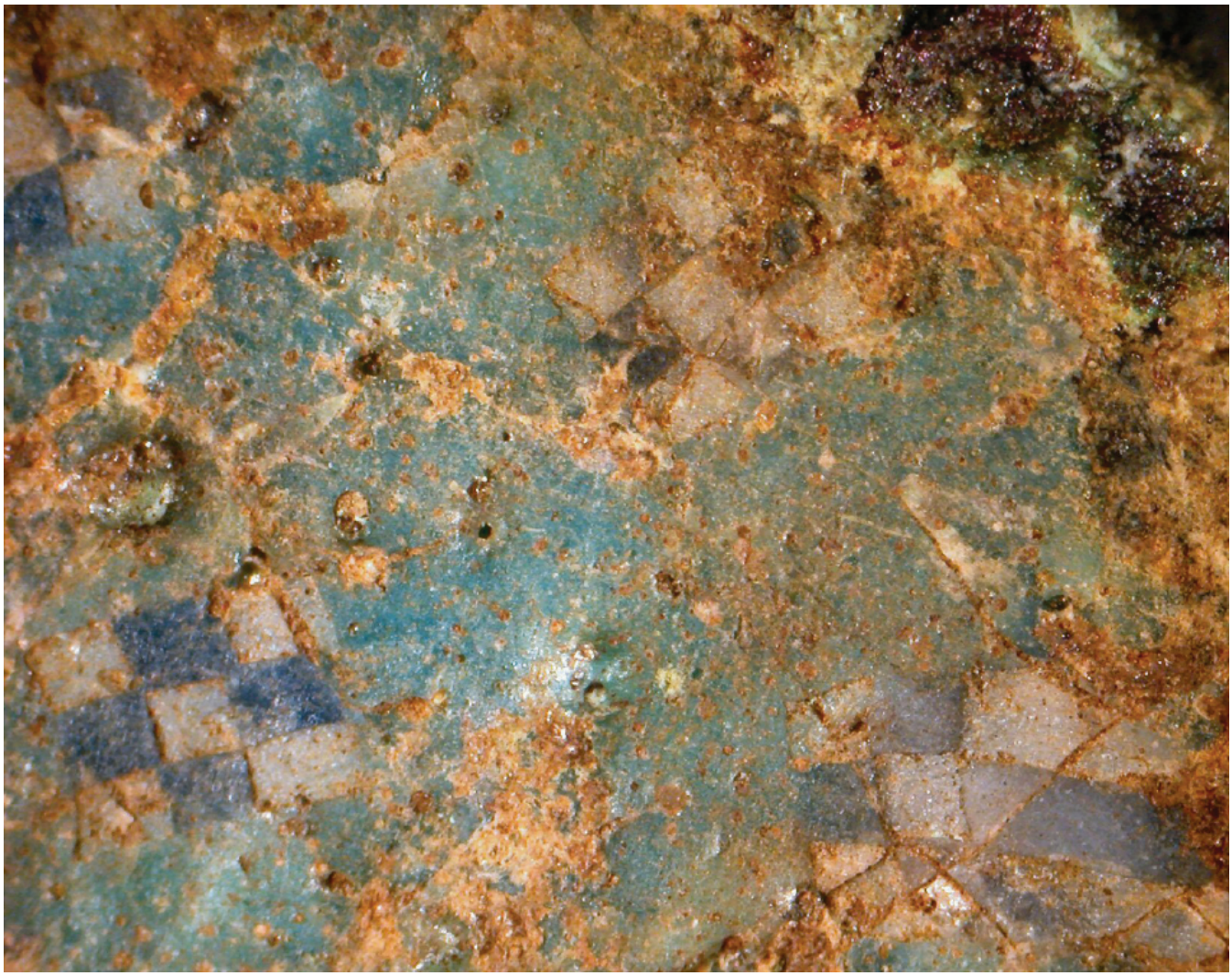

Fig. 17.5: The turquoise field contains scattered 3x3 white and blue millefiori blocks; image width c.9mm (NN202).

Some enamel fields have spots of a second colour in them. This effect was achieved in a number of ways. Most commonly spheres or irregular droplets of glass were added to an enamelled field and were pressed or sank into the softened glass. When cold, the surface was ground flat, leaving hemispheres (showing as circles) embedded in the field (Fig. 17.6). In a few cases larger, flat discs of dark green or black glass were floated on the surface of the enamel and then ground flat in the same way. Sometimes glass spheres, again usually dark green or black, were added to a field of softened enamel but, unusually, were not polished flat; the undulating, fire-polished surface of the enamel is still visible (Fig. 17.7). In a few cases the spots were cylinders of glass, cut from a rod, pressed into the enamel field and when cold polished flat, a technique that has parallels with millefiori blocks set randomly into

an enamel field. In some cases the spots were of one colour surrounded by a second or even third concentric layer (Fig. 17.8). In these cases the technique seems to have been similar to the first one described, but with a spot of a second colour added in the centre of the original one, as shows clearly on a three-colour stud that was not ground flat (Fig. 17.9).

Fig. 17.6: Spots formed by hemispheres of red and white enamel set in a blue field. Note the parallel polishing marks; image width c. 7mm (NN 146).

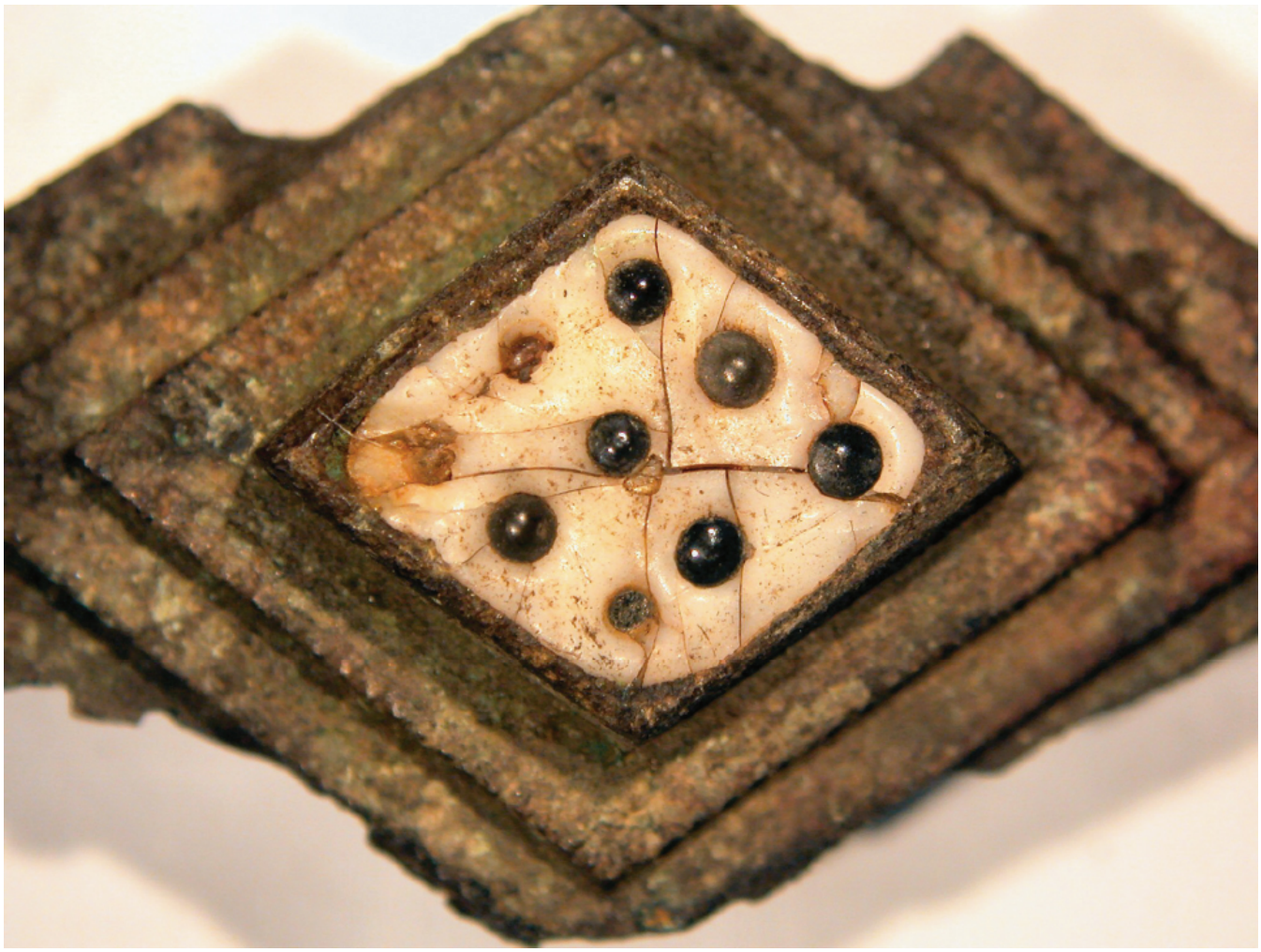

Fig. 17.7: Spheres of black glass (some now lost) pressed into white enamel that retains its fire-polished surface; image width 14mm (NN 253).

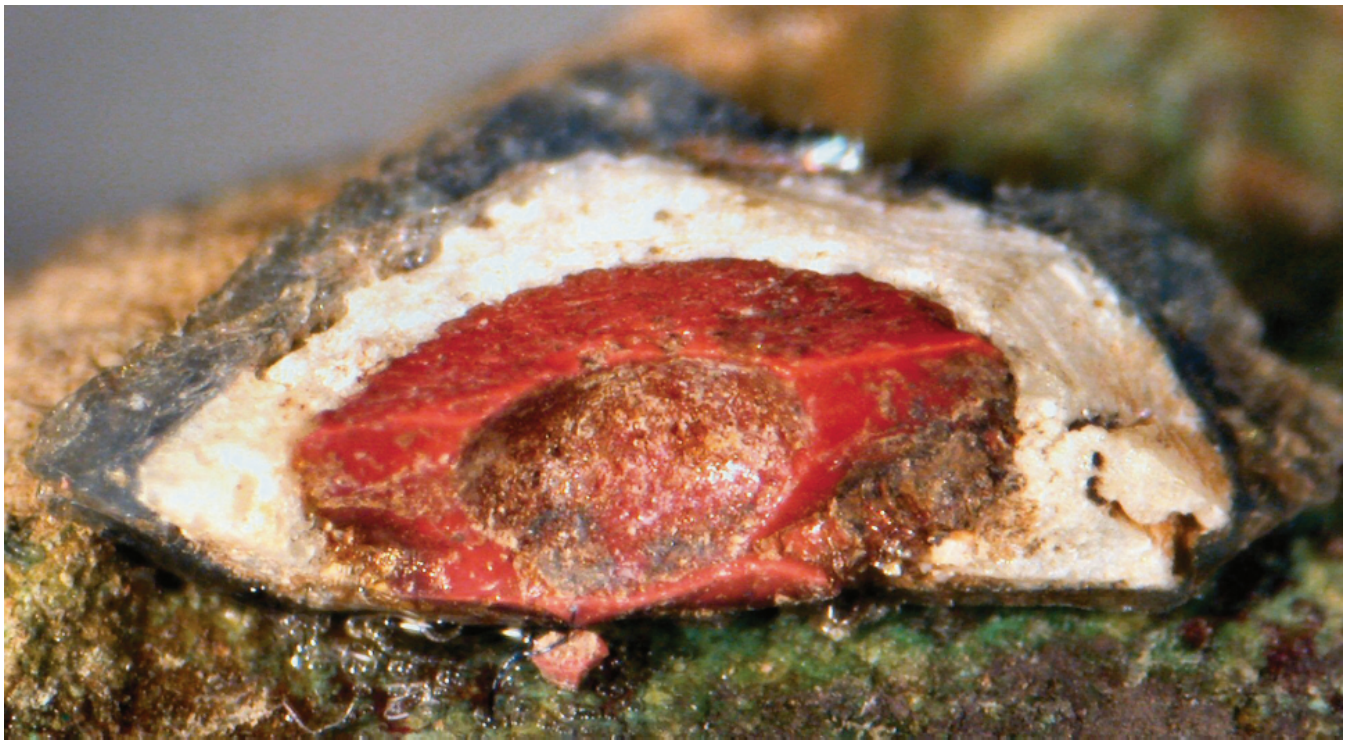

Fig. 17.8: A cross-section of one of the white and red concentric spots in a blue field, showing how the enamel is distorted as each new colour is added; image width c.5mm (NN 135).

Fig. 17.9: A three-layer concentric spot of white, black? and yellow enamel that was not ground flat; stud diameter 4.5mm (NN 165).

Occasionally the enamel is a mixture of different colours, with no regular pattern discernible (Fig. 17.10). These mixed enamels sometimes show a repeating colour sequence, suggesting they were made by fusing fragments of multi-coloured glass onto the metal, possibly the ends of millefiori rods that were too distorted to use, or even fragments of mosaic glass vessels. Mixed enamels are also used as blocks in juxtaposed patterns. Some enamels with a marbled appearance were probably meant to be a plain colour, as with the swirls of 'black' mixed with opaque red (Fig. 17.11). Typically the 'black' is actually colourless glass but it looks black as the surrounding opaque red glass stops light shining through it. Red and colourless glass is a not uncommon mixture, being used especially for window glass in both Roman and later times (Price 1993, pl. I; Cramp 1970, pl. LIVb).

The visual appearance of enamels

Ancient glass can show varying degrees of opacity from fully transparent through translucent to partly and fully opaque. Unlike much Roman glass, enamel was usually opaque. This was to prevent the underlying metal, almost always a copper alloy, showing through as this would affect the perceived colour. Opacity can be due to colour intensity, bubbles in the glass (rare in enamels), the inclusion of opacifying agents (see below) or a mixture of these factors. A range

of opaque and translucent colours are found in Roman enamels. Those that are always opaque are red, orange, yellow and white while golden brown, purple and 'black' are always translucent; green, turquoise and blue can be either. The frequencies with which each colour was used are very varied, and there are significant variations with the style of enamelling, for instance white and yellow are far more common on objects decorated with spots or millefiori, while the main use for orange is on objects decorated with juxtaposed blocks of enamel (Bayley and Butcher 2004, 49–50 and fig. 35).

Fig. 17.10: Mixed enamel with areas of opaque red and yellow and translucent purple and green; image width 10mm (NN 208).

The enamel would normally have been applied as a moistened powder mixed with an organic binder but sometimes a slab of glass appears to have been cut roughly to shape, softened and pressed into place. Bimson (1987, 169) believes this is the only way opaque red enamel could have been used as re-melting would have destroyed its colour. Once fused, the enamel was sometimes left with its 'fire-polished' surface, but the very flat surfaces of well-preserved enamels, and the parallel lines sometimes seen on them (Fig. 17.6), suggest that normally the surface was ground and polished smooth. This polishing would also remove any discoloration cause by heating.

Much surviving enamel has lost its original glassy appearance and bright colour. Examination at low magnification (×10 or ×20) can often identify small areas where the original colour survives, though some enamels weather so badly that their present appearance can be

misleading (Bayley 1987a; Bayley and Butcher 2004, 48–9). Black, blue, turquoise, white and yellow are relatively little affected while red and orange often appear greenish, buff, grey or nearly black. Care must therefore be taken both in describing decayed enamels, and in accepting descriptions made without the benefit of careful, microscopic examination. A further problem is that translucent turquoise glass was sometimes used as an 'undercoat', to partly fill large fields before a final coloured layer of glass was added. Thus where only traces of translucent turquoise enamel survive at the base of a field, it may not have been the intended final colour.

Fig. 17.11: Marbled opaque red and colourless enamel; image width 14mm (NN 188).

The composition of enamels

It is generally accepted that most Roman enamels were made by adding colorants and/or opacifiers to a base glass that had a soda-lime-silica composition, similar to contemporary vessel and window glass. This has been specifically demonstrated for raw red enamel from Castleford (Bayley 2005, table 2), and can be inferred from most other enamel analyses. Lead is found almost universally as an additive and it has been suggested that it may have been added to influence the physical properties of the glass such as its melting point, expansion coefficient, and the ability of the enamel to 'wet' the metal more effectively, forming a better bond (Bateson and Hedges 1975). Lead was also essential for the development of some

opaque colours. However, opaque colours of very similar composition, including lead content, are found in other Roman glasses such as vessels and mosaic tesserae (e.g. Henderson 1991b). It thus seems likely that in most cases enamellers were using available coloured glasses and there was no specific manufacture of enamels or addition of lead to glasses used as enamels (but see below for red enamels).

Colorants and opacifiers

Enamel is coloured by small amounts of one or more metals. If a metal is dissolved in the enamel it usually appears transparent. The colour produced by a dissolved colorant is influenced by a number of factors, including the composition of the base glass and the concentration and oxidation state of the colorant. For example, iron-containing glasses can range from brown through green to blue as the furnace conditions become more strongly reducing; large amounts of iron produce darker colours, or even make the glass appear black. When a decolouriser such as manganese or antimony is also added to the glass the redox equilibria become more complex and the range of possible colours increases. Larger amounts of manganese give a range of golden brown to pink, purple and even black colours.

An alternative colouring mechanism is adding compounds that result in the formation of coloured crystals in the enamel. If the crystals are very small and numerous, they cause light entering the enamel to be scattered so it appears opaque rather than transparent. Examples of crystalline colorants (which also act as opacifying agents) are white calcium antimonate, yellow lead antimonate and red or orange cuprous oxide. Other opaque colours were produced by adding an opacifying agent to a coloured, translucent glass, though care was needed as too large a quantity of opacifier would mask the translucent colour.

Lead on its own does not produce colours but it plays two important roles. It modifies the structure of the glass, thus altering the colours produced by other dissolved metals, and it also produces the right environment within the glass for coloured crystallites to precipitate, producing opaque enamels. This is particularly important with red and orange enamels where the presence of lead helps the dissolution of copper in the glass melt, and aids the growth of large cuprite (cuprous oxide) crystals as the glass cools, which give it a bright red or orange colour. Some red enamels have a far duller colour, and contain much lower amounts of lead and copper, more iron and, for some, more magnesia and potash too (Henderson 1991a). These dull reds have most of the cuprite present as sub-micron particles which explains their colour, as Freestone (1987) has shown for earlier opaque red glasses. Unfortunately it is not possible to say whether these different compositions of red enamel that Henderson has identified can be linked to enamelled objects made in different parts of the Roman Empire as he has published no details of the objects he analysed.

One major outcome of the work by Bateson and Hedges (1975) and Biek *et al*. (1980) was the identification of colorants and opacifiers (Table 17.1) and subsequent analyses of Roman enamels have found the same range of colorants (e.g. Henderson 1991a). The original hope was that variations in the use of particular colorants would help identify different traditions of enamelling, but the consistency of the amounts of major and minor elements detected in enamel analyses, other than for red enamels, show that the materials used were relatively uniform across large parts of the Roman Empire, suggesting the glass may have been made in a limited number of centres and then traded widely.

Enamel colour	Opaque	Translucent (metal in solution)
White	calcium antimonate	–
Turquoise or blue-green	[2]	copper or iron
Dark blue	[2]	cobalt
Purple	–	manganese
Black	[1]	iron
Red	copper or cuprous oxide	–
Orange	cuprous oxide	–
Yellow	lead antimonate	–
Golden brown	–	manganese
Green	[3]	iron, or copper (in a lead-rich glass)

Notes
1 'Opaque' blacks are normally very dark translucent olive green glass.
2 Opaque turquoise or blue enamel is usually translucent glass containing some added calcium antimonate.
3 Opaque green enamel is usually translucent glass containing added lead antimonate. Many enamels that look opaque green are decayed reds or oranges.

Table 17.1: Summary of the colorants and opacifiers identified in Roman enamels (based on Biek et al. 1980, with additions)

Evidence for enamelling

Enamelled objects provide some evidence of the techniques used to produce them, as outlined above. To this can be added evidence from workshops, manufacturing debris and raw materials.

Bateson (1981, 99–107) considered the evidence for manufacturing sites and came to the conclusion that the evidence one would expect was no different from that on a site where non-ferrous metals were worked. He went on to identify possible manufacturing sites, but most he dismissed as dubious. Some sites which early publications cited as places where enamelling was carried out have, on reexamination, failed to provide any definite evidence for this. A British example is Nornour in the Isles of Scilly where the many T-shaped brooches are now thought to be votive offerings rather than local products (Butcher 1977; in press). Similarly, in Belgium the villa d'Anthée is not now though to be the origin of many of the continental enamelled 2nd-century brooches found there (Spitaels 1970).

So far we have no Romano-British workshops where we can positively demonstrate that enamelling took place. However, there are a few collections of clay moulds that were used to cast metal objects that would then have been enamelled, most probably in the same workshop, and also a number of finds of raw enamel.

Clay moulds for enamelled objects

The main feature of moulds for objects that were to be enamelled is upstanding parts of the design that created the sunken fields in the metal casting that were then filled with enamel. If the clay used for the mould was fine enough very detailed ornamentation could be reproduced but because the mould fabric was not strong the fine detail was usually damaged in removing the casting, one reason the mould could not be reused.

Two large collections of moulds are particularly exciting. Those from Compton Dando, on the Mendips, are for a range of headstud and T-shaped brooches that can be dated typologically to the later 1st and 2nd centuries (Bayley and Butcher 2004, 35). These types are most commonly found in south-west Britain, and the longstanding assumption that they were therefore made in the region is now supported by hard evidence. The moulds had back and front valves, the fronts carrying the relief that produced small triangular and lozenge-shaped fields in the finished brooches (Bayley and Butcher 2004, pl. 2).

The second group of moulds come from a late 1st-century context associated with the fort in Castleford, Yorkshire; they were for making multi-part enamelled flasks that may have held oil for use in the baths (Bayley and Budd 1998). At least two vessel forms and twenty different patterns of enamelling are represented. Some of the patterns have small geometric fields while on other moulds the enamel provides a background to reserved metal in curvilinear and foliate designs. No vessels of the main form of flask represented by these moulds (Bayley and Budd 1998, fig. 70) are known in Britain, but there is one 19th-century find from Pinguente in Istria, now in the Kunsthistorisches Museum in Vienna (Inv. VI 1197; Henry 1933; Künzl 2008, 24). Another flask found more recently in a late 1st-century grave in Nijmegen is of a globular form (Koster 1997), but with bands of small geometric fields of enamel whose patterns duplicate those on some of the Castleford moulds (Bayley and Budd 1998, fig. 77). It is not surprising that so few complete vessels survive, but their Empire-wide distribution is interesting and can be explained in a number of ways: there may have been a thriving export trade in British-made flasks; the craftsmen who made them could have travelled widely or, perhaps most likely, the flasks were cherished by their owners who kept them as they travelled around. Perhaps they were considered souvenirs of a visit to Britannia as has been recently suggested for enamelled paterae depicting Hadrian's Wall (Breeze 2012).

Crucibles

Crucibles are refractory ceramic containers used for working materials such as metals and glass (Bayley and Rehren 2007). While metal-working crucibles are well-known, those used for glass-working in the Roman period are less common, though they have been found on an increasing number of British sites (e.g. Frere 1984; Bayley 1987b; Jackson *et al*. 1998). None of them contain highly-coloured glass that could have been used for enamelling which suggests that enamel-making or -melting was a specialist activity and not part of the normal glass-working repertoire.

Fig. 17.12: The largest lump of raw red enamel from Castleford, Yorkshire.

There are a few Roman crucibles that contain coloured glass which are far smaller than the glass-working crucibles noted above. Some late Roman crucibles sherds from Catsgore, in Somerset contained opaque yellow glass (Biek and Kay 1982) but the colorant in the glass is lead-tin yellow which has not been identified in Roman enamels, though it became common in late- and post-Roman glass beads (Bayley 1999) and is also known from the late pre-Roman Iron Age (Werner and Bimson 1967). Another group of crucibles with opaque yellow and white glass in them come from Buckden, now in Cambridgeshire, but they were associated with pagan Saxon pottery and again the glass is opacified with tin compounds (Biek and Bayley

1979), while Roman enamels are normally antimony-opacified (e.g. Bateson and Hedges 1975).

One group of over 20 1st-century crucible sherds from Chichester that held opaque red glass were initially identified as evidence for enamelling (Bayley 1978) but have now been shown to have been used for precious metal refining (Bayley 2005; 2009). They were associated with parting vessels, which were used to separate silver from gold, and the red glasses are refining slags similar to those identified by Rehren and Kraus (1999) at Xanten. The glass has a very different composition to Roman red enamel, with little soda or lime and far less silica, and also contains a significant amount of silver – which has not so far been detected in Roman enamels. Interestingly Stapleton *et al*. (1999) have found early medieval enamels with compositions of this type, including one containing a silver-rich prill.

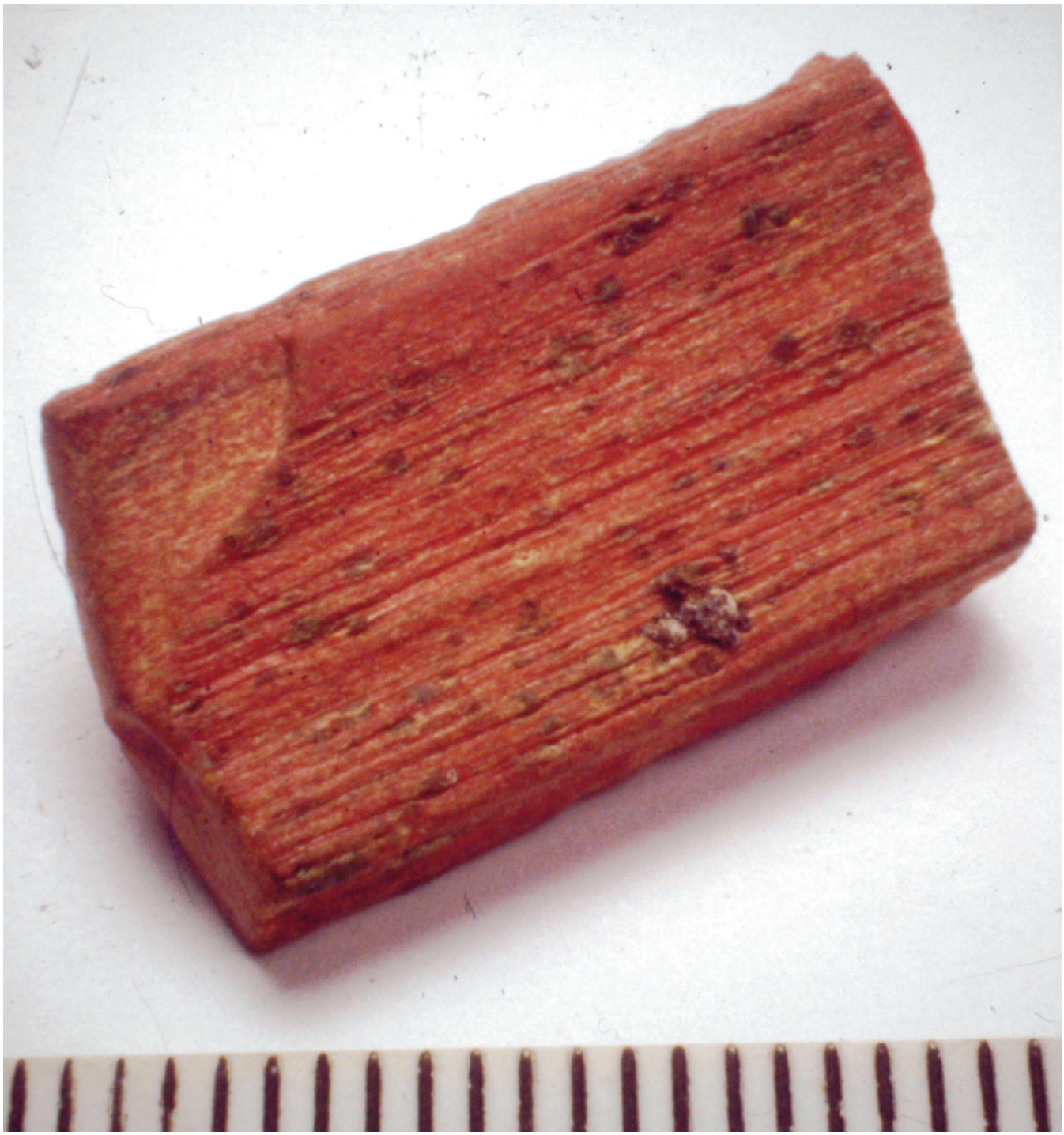

Fig. 17.13: Strip of raw red enamel from Heybridge, Essex; scale in mm.

Raw enamel

In Roman Britain, opaque red glass is most commonly used as enamel, so it is reasonable to assume that any pieces found were intended for use as enamel. There are two relatively recent finds of this raw enamel: from Heybridge in Essex (Bayley 2003) and from Castleford in Yorkshire (Bayley 2005; 2006). To these can be added old finds from Fish Street Hill in London (Freestone *et al*. 2003) and Tara in Ireland (Stapleton *et al*. 1999); all of them have similar compositions. Nicholas Lane, close to Fish Street Hill, is recorded as the source of '… crude

lumps of green enamel …' (Wheeler 1946, 32) which may be more of the same material, the green being only a corroded outer skin like that on the lumps from Castleford (Fig. 17.12).

The Heybridge enamel came from a pit on the northern edge of the settlement, provisionally dated to the mid-late 1st century AD. It was a strip of opaque red glass, 21mm long with a rectangular cross-section 12 by 3mm (Fig. 17.13). The surface striations and irregular ends suggest it had been cut or broken from a longer strip that had been drawn down from a larger-sectioned block of softened glass. It is obviously not a finished object and must therefore be raw enamel, part of a craftsman's stock of materials.

Trenches 44 and 51 in the vicus at Castleford have produced four lumps of raw red enamel; the largest piece was 56mm long (Fig. 17.12). Their external surfaces were corroded and so looked pale green or brown but recent fractures showed opaque red glass in the interior of three of the pieces, and a translucent dark green/black glass in the fourth; the red colour was due to large feathery, dendritic crystals of cuprite. As analysis of the Castleford enamel showed the bulk compositions of all four glass lumps were very similar, it is possible that they were originally pieces of a single block of glass (Bayley 2005). The piece with the atypical appearance could be a part of the block where the colour had not 'struck'. Cable and Smedley (1987, Fig 2) have shown that a single melt of red glass can have zones of different colours; in one example these were both dull and bright opaque red, opaque orange and translucent green, similar to the variations in the Castleford enamel.

The findspots of the raw red enamel from Castleford are all contexts with burnt samian ware pottery, which Hilary Cool (pers comm) interprets as being debris from a fire that was spread fairly widely in the mid-2nd century. This date for the raw enamel and its location in the vicus, 300m south of the pit in the fort containing the moulds mentioned above (Abramson *et al*. 1999, fig. 8), means it is unlikely to relate to the vessel-making; it may instead have been intended for enamelling the brooches that were then being made in Castleford (Bayley 2005).

Other possible sources of enamel

It is not totally unexpected that the only finds of raw enamel are red as this is one of the commonest colours on Roman enamel work (Bayley and Butcher 2004, 49). However it is not the only colour used, and possible sources for blues, which are nearly as common (Bayley and Butcher 2004, 50), and to a lesser extent other colours, need to be considered.

In Britain strongly-coloured glass vessels, both translucent and opaque, are occasionally found, most often on sites occupied from the Claudian conquest to the early Flavian period (Price and Cottam 1998, 15). This opaque glass, or translucent glass if it subsequently had an opacifier added, could thus be a source for early enamels, but the floruit for enamelling is later in the 1st and into the 2nd century so other sources must also be sought as it is unlikely that sufficient strongly-coloured glass vessels would still have been available.

Opaque glass was used to make opus sectile panels – but they are not known in Britain – and also trinkets such as gaming counters and beads. These could have been recycled into enamels, or the glass used to make them could also have provided raw glass for use as enamel.

Glass tesserae are relatively frequent finds in occupation deposits (e.g. Bayley 1985; Cool and Price 1998) though they are rarely found in mosaics in Britain. Almost all are opaque and so could easily have been used as enamel. Looking forward in time parallels can be drawn with Theophilus' 12th-century description of using mosaic tesserae from ancient buildings as enamel (Hawthorne and Smith 1979, 59). The majority of the tesserae known from Britain are

blue, identified above as the second most common colour of enamel. Indeed, the excavations in Castleford that produced the lumps of raw red enamel also produced large numbers of opaque blue glass tesserae (Cool and Price 1998); there is nothing to prove they were raw material for enamelling, but their findspots are certainly suggestive in a settlement where no fine mosaics are known.

Colchester Archaeological Trust has recently found a cache of over 200 glass tesserae (together with more massive edges of circular raw glass cakes from which they were presumably cut) at West Clacton which Hilary Cool drew to my attention. Several shades of blue predominate though a range of other colours are also represented (Paynter and Kearns 2011, table 1). This shows that tesserae in most of the colours used in enamelling existed in Britain, so finds like this cache may have been the stock in trade of an enameller rather than a mosaicist.

Glass production

Recent work has suggested that much of the vessel glass produced in the Western Empire at this time was made by re-melting bulk glass produced in the eastern Mediterranean (e.g. Foy and Nenna 2001). For glass tesserae the major demand was in the Mediterranean parts of the Empire where they were used in quantity in mosaics so production of coloured opaque in those areas is therefore most likely. James (2006) notes that in the Byzantine period mosaics would have required tons of glass which continued to be made in the eastern Mediterranean. It would have been coloured in a specialist factory before being traded as circular cakes of glass 5–30mm thick and up to 400mm in diameter from which tesserae would have been made on site. The relatively small quantities of tesserae found in Britain, like those from West Clacton mentioned above, were most probably imported – a few sacks now and again would have been plenty to supply the demand here.

In contrast to these bulk glass industries, specialized commodities that were used in small quantities, such as the raw enamel found at Heybridge or Castleford, would almost certainly have been manufactured in a small-scale workshop. The tradition of using opaque red enamel was well established in Britain and France in the pre-Roman Iron Age (Hughes 1972), so raw red enamel must have been readily available here to late Iron Age craftsmen. Enamelling continued to be a relatively common decorative technique after the Roman conquest, so it is possible that raw enamel was made in Britain but it could also have been produced almost anywhere else in the Roman Empire. In this context the lead isotope analysis of the Tara Hill red glass ingot, which has a typical Roman enamel composition, should be noted as it shows the lead in it was not likely to have come from a British source though lead is plentiful in the British Isles (Stapleton *et al*. 1999, 915). As most enamels contain significant amounts of lead, it is possible that further lead isotope analyses will throw more light on the sources of the glass used as enamel in Romano-British workshops.

Conclusions

Enamelling would have been carried out either by an artisan who lived and worked at one place, or perhaps by one who travelled around in search of business. It is likely, though not yet proven by archaeological finds, that enamelling and casting of the metal objects would have been carried out at the same place, and by the same craftsman; the skills required – manual dexterity and the ability to work at high but carefully controlled temperatures – were

the same. There is now evidence to support the assertion that enamelling was carried out in Roman Britain, but what is still needed are workshop assemblages so the scale of their operation and the methods of the craftsmen can be better understood.

The lumps of glass from Heybridge and Castleford have been identified as raw red enamel; their composition and structure compares well with examples of raw glass from other sites and that used in Roman enamelled objects. Further quantitative analyses of enamels, tesserae and other coloured glass trinkets could provide a better understanding of the sources of the glass used to make them, and would demonstrate the reality, or otherwise, of the potential relationships outlined above.

The study of Roman enamels has come a long way, but although the new information has answered some questions it has posed others – so the work needs to go on.

Acknowledgements

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18

BEYOND THE CHANNEL! THAT'S QUITE A DIFFERENT MATTER. A COMPARISON OF ROMAN BLACK GLASS FROM *BRITANNIA*, *GALLIA BELGICA* AND *GERMANIA INFERIOR*

Peter Cosyns

Introduction

This paper contrasts the Roman black glass from *Britannia* with finds from *Gallia Belgica* and *Germania Inferior*. This comparison shows regional and interregional differences as well as similarities. Black glass vessels are present both on the Continent and in *Britannia* in the 1st century AD and again from the late 2nd to the middle of the 3rd century AD. Black glass jewellery, which is closely related to that in jet, is introduced later and has a longer life, into the 5th century AD. In relation to jewellery a distinct difference is noticeable between the more continentally-orientated south-east England and the rest of Roman Britain. While also true of many other materials such as pottery, brooches and jet, this observation can assist in clarifying hypotheses generated from findings on the Continent.

The colours of black

'In our classification of glass we include also 'obsidian' ware (*obsiana*), so named from its resemblance to the stone found by Obsius in Ethiopia. This stone is very dark in colour and sometimes translucent, but has a cloudier appearance than glass, so that when it is used for mirrors attached to walls it reflects shadows rather than images.

Gems are frequently made of it, and we have seen also the solid obsidian statues of Augustus of Revered Memory, for the substance can yield pieces bulky enough for this purpose. Augustus himself dedicated as a curiosity four elephants of obsidian in the temple of Concord, while the emperor Tiberius for his part restored … an obsidian statue of Menelaus … This statue proves that the origin of the stone, which is nowadays misrepresented because of its similarity to the glass, is of an earlier date …' Pliny, *NH* 36, 196–197 (Eichholz 1962)

Quoting Pliny the Elder, Thea Haevernick emphasized that in Roman times no black glass existed, interpreting true black glassy objects as obsidian, and only describing the very dark brown, purple or green objects as manufactured in glass (Haevernick 1963, 123). Pliny's confusing observations on black glass and obsidian, however, give scope for different

interpretations because obsidian too is found in a range of colours. Pliny describes the existence of sculpture in obsidian in the early Roman imperial period; a portrait supposedly in obsidian is in the Graeco-Roman Museum of Alexandria (GRM 3536). On the other hand, the British Museum holds the cast foreleg fragment of a more than life-size statue of a horse in very dark purple glass that appears black (Harden *et al* 1987, 28, no. 6), and there are imitation *nicolo* gemstones for finger rings, made using black glass with an opaque white glass top layer that looks blue, *e.g*. Bonn – Medizinische Klinik (Heimberg 2002, 154–156, fig. 39a–b). These examples suggest that the Romans were not able to distinguish manufactured glass from obsidian. The rarity of so-called black glass sculpture makes it impractical to discuss this further here, although its existence must be mentioned.

The discussion above assumes that black (glass) never occurs, causing a primary problem in the methodology for researching something that *per se* does not exist, though it is used and referred to by the Romans. The problem is therefore not only to create a scientifically-based objective reference system, but also to combine it with Roman perception of colours and their meaning. And to understand what black means or stands for, we need to know how we define black. What is black and how did the Romans see it? It is commonly known that black and white are not considered as colours and that the former absorbs all the colours of the spectrum, while the latter reflects them. Nevertheless, in practice so-called black and white glass will always have one dominant tint. Black glass is so densely coloured that it is usually said to be opaque (Bayley 1999, 90; 92). The investigating eye is therefore the best medium to discriminate the true colour of black glass, particularly with the assistance of strong transmitted illumination. In this 'black glass' one colour will become visible, so it is always possible to determine the true colour of black glass – which can be green, brown, purple, blue or even red. It is therefore important to know which colorant was added to the glass to make it appear black, and to take this information into account when investigating chronological and geographic distributions.

The combination of typology with chromatography and chemical analysis is a necessary approach in the challenge to solve the following fundamental questions: How did the Romans obtain black glass? Were different black colours produced in different periods and/or different regions? What are the technical factors that link to chronology, distribution patterns and origin of the material? Publications referring to black glass objects, unfortunately, do not always distinguish its true colour from its black appearance; they may only note its black appearance, or may identify the hue without mentioning that the object appears black. When dealing with glass the identification of its colour remains very important and in research on (Roman) black glass this seems to be even more fundamental as many colours can appear black. The question 'When do we start speaking of so-called black glass?' is being investigated by absorption spectroscopic analyses at the Department of Applied Physics of the Free University Brussels (VUB-TONA).

Vessels

'There is also the artificial "obsidian" glass which is used as a material for tableware, this being produced by a colouring process, as is also the case with a completely red, opaque glass called in Greek 'blood-red ware' (*haematinum*).' Pliny, *NH* 36, 198 (Eichholz 1962)

Vessels made of black glass were fashionable during two periods in the western provinces and were produced by various techniques. The first peak dates to the 1st century AD, roughly from the Tiberian to the Flavian period, and includes cast as well as free-blown vessels (Cosyns and Fontaine 2009). From the middle of the 2nd century to the last quarter of the 3rd

century black glass was re-introduced in the north-western provinces for the production of vessels (Cosyns and Hanut 2005; Cosyns *et al*. 2006). During this later period black glass vessels were essentially free-blown, though mould-blowing was used occasionally (Isings and Van Lith 1992, 17–18, fig. 19). The later vessel shapes were mainly tableware, almost exclusively for drinking and pouring – beakers, cups, bowls, jugs and jars – while in the former period *unguentaria*, storage jars and palettes or stands were used in addition to drinking vessels.

The production of black glass vessels in the 1st century echoed the success of strongly-coloured monochrome glass vessels during a large part of the Julio-Claudian Dynasty (early to mid 1st century AD). However, from the reign of Nero the use of colourless glass became popular all over the Roman Empire, causing a decline in strongly-coloured monochrome glass vessels in the third quarter of the 1st century. While this change in fashion is the reason for the disappearance of black glass vessels by the end of the 1st century, socio-economic reasons were undeniably the grounds for the later disruption in black glassware production in the second half of the 3rd century. Black glass vessels, like the well-known contemporary snake-thread-decorated colourless glass vessels and other characteristic shapes in the northwestern provinces, such as Mercury-bottles, disappear between AD 250 and 280. Yet some single finds of late Roman date do occur, such as the small black glass toilet bottle from inhumation grave 5530 at Krefeld-Gellep (Pirling and Siepen 2003, 69, no. 5530,4, pl. 133,2). The chaotic crisis periods from the middle of the 3rd century AD onwards, culminating in the revolt of the Gallic Empire of AD 260–274 under Postumus and Tetricus, the Frankish invasions of AD 275–276, the *Bagaudae* revolt of AD 285–286 and Carausius' revolt of AD 286–297, are a credible series of reasons why a whole range of glass fabrics, once produced in the northwestern provinces, came to an end. It is, however, not the purpose of this paper to discuss the impact of socio-economic changes on glass production in the 3rd century AD.

It is significant that the distribution of black glass vessels was throughout the Roman Empire during the 1st century, though in marginal quantities, while in the late 2nd and early 3rd century their circulation seems to have been limited to *Gallia Belgica* and *Germania Inferior* in particular, with some finds from the neighbouring areas, such as the south-east of *Britannia*, the north of *Germania Superior* and *Gallia Lugdunensis*. The exception that proves the rule is a find of a one-handled jug (Cosyns and Hanut 2005, form 11; Isings form 120 variant) from Grave 4 of the cemetery at Ptuj in Slovenia (Tušek 1993, 411–412, pl. 6.1; Lazar 2003, 130–131, fig. 39).

It is peculiar that most black glass vessels from contexts dated to the 1st century AD on Romano-British sites, *e.g*. Colchester, Caersws, Fishbourne and Carlisle, are limited to cast palettes or stands (Cosyns and Fontaine 2009) and that they are restricted mainly to contexts of domestic character in civil settlements. Only the unpublished material in the London Archaeological Archive from excavations in Greater London shows a greater range of shapes, incorporating an unguentarium from the Drapers' site (DGT06; pers. comm. John Shepherd). There is a much wider variety of vessel forms in continental contexts, and most material is found in rich cremation burials, sometimes tumuli, containing luxury grave goods (Cosyns and Hanut 2005, 117, tab.1). Usually the black glass vessels were put into the grave at the end of the burial rite and are therefore mostly intact. Two exceptions, however, show vessel fragments deformed by the heat of the pyre, a small bulbous jar (Cosyns and Hanut 2005, form 4; Isings form 94) from the Siesbach barrow (Abegg 1989, 209, fig. 17) and a beaker (Cosyns and Hanut 2005, form 1; Isings form 36b) from a grave at Auvelais (unpublished, Musée Archéologique Namur, inv. no. A4604C). These rich graves also show diversity in decorative patterns created on black glass vessels, such as the applied opaque white (or blue)

glass threads marvered into the core glass and combed into a feather pattern on the *amphoriskos* from Elsdorf-Esch (Gaitzsch 1999, 79) and the jug from Weilerwist-Hausweiler (Follmann-Schulz 1992, 21–22, no. 10). Straight upright or diagonal festoon patterns are also found, the former for example at Avenches (Martin Pruvot 1999, 230, pl. 149, no. 1490), Heerlen (Brouwer 1991, 47, no. 16) and Nijmegen (Isings 1964, 176, fig. 4) and the latter at Siesbach (Abegg 1989, 209, fig. 17) and Cologne (Isings 1964, 176, fig. 5). Another type of decoration is the indented body, known for example at Faulquemont (Cabart 2005, 20–21, Cosyns *et al*. 2006, 37, fig. 6), Mettet (in the Musée Archéologique, Namur, inv. no. A4606C; Mahieu 1919, 163; Isings 1957, 47; Isings 1964, 179, no. 18) and the piece of unknown provenance in the Metropolitan Museum of Art, New York (inv. no. 17.194.166). The total absence of these decorated black glass vessels on Romano-British sites is striking.

Colchester is by far the richest Romano-British site with a wide range of black glass vessels. One fragment comes from a bowl with a wide everted rim and straight-sided inward-sloping body. The rim is ground flat on the upper surface with mouldings at the rim edge and at the junction with the body (Cool and Price 1995, 32; 35, fig. 2.10, no. 201). Another fragment has one deep wheel-cut line on the interior of the rim and raised moulding at the junction of the rim with the body (Cool and Price 1995, 32; 35, fig. 2.10, no. 196). Further fragments are a base fragment of a bowl with a flat base and a high, out-splayed base ring (Cool and Price 1995, 32; 35, fig. 2.10, no. 206), an out-turned rim fragment of a beaker (Isings form 36b) with fire-rounded edge and side sloping inwards (Cool and Price 1995, 93, fig. 5.17, no. 615), a horizontally out-bent, stepped rim fragment of a bowl (Isings form 42) with fire-rounded edge (Cool and Price 1995, 100, fig. 6.4, no. 694), a fire-thickened rim fragment of a bowl with marked external lip and a straight side sloping in (Cool and Price 1995, 103, fig. 6.7, no. 713). Most of these fragments are of unusual shapes but unfortunately nearly all are residual finds from later contexts or unstratified finds, which does not help with dating. It is striking that Colchester shows a whole range of black glass vessels from mid-1st century contexts onwards until the 4th century (Cool and Price 1995) while there is no black glass jewellery (Crummy 1983).

The distribution pattern (Fig. 18.1) of two widespread vessel forms is eye-catching – the carinated beaker with out-turned fire-rounded rim (Isings form 36b; Cosyns and Hanut 2005, form 1) and the bulbous jar (Isings form 94/AR 104/Trier 37–38; Cosyns and Hanut 2005, forms 4–5). Despite the small number of fragments of the beaker type appearing in *Britannia* (at Colchester), their occurrence is the westernmost part of a distinctive east-west distribution that lies mainly within *Germania Inferior* and the northern part of *Gallia Belgica*, a region now known as the north of France, Belgium, the southern Netherlands and the lower Rhine region in Germany; there are examples from Tienen, Velzeke, Colchester, Boulogne-sur-Mer and Amiens (Cosyns and Hanut 2005, fig. 1). The total absence of black glass globular jars/beakers in *Britannia* is not surprising as their distribution has a north-south axis with no finds in most of *Gallia Belgica* (Fig. 18.1). This vessel shape seems only to occur in the south of *Germania Inferior* and the east of *Gallia Belgica* with examples from Matagne-la-Petite (unpublished, VIOE), Liège (Halbertsma 2006, 31, no. 20), Bois-et-Borsu (Cosyns and Hanut 2005, 114, form 4), Faulquemont (Cabart 2005, 20–21, fig. 3), Siesbach (Abegg 1989, 209, nos 312, 319–26) and Avenches-En Chaplix (Martin Pruvot 1999, 230, no. 1490; 199, nos 1258–59, 1261).

A third vessel type, a shallow plate or bowl with fire-rounded rim (Isings form 42), is so far only known from Avenches (Martin Pruvot 1999, 201, nos 1274–1275, 194, no. 1217), Colchester (Cool and Price 1995, 100), the *vicus* at Castleford (dating mid 2nd century; Cool and Price 1998, 156, fig. 53, no. 62) and Deansgate, Manchester (late 1st to early 2nd

century; Cool and Price 1995, 100). The known examples are so far too few to allow any distribution pattern to be suggested, but it may have a wider range than the two other vessel shapes.

Fig. 18.1: Map showing all sites discussed in this paper [•] : 1. Abbeville; 2. Amiens; 3. Boulogne-sur-Mer; 4. Eauze; 5. Faulquemont; 6. Sainte Menehould; 7. Auvelais; 8. Bois-et-Borsu; 9. Braives; 10. Cortil-Noirmont; 11. Éprave; 12. Franchimont; 13. Furfooz; 14. Grobbendonk; 15. Han-sur-Lesse; 16. Liège; 17. Matagne-la-Petite; 18. Mettet; 19. Oudenburg; 20. Overhespen; 21. Penteville; 22. Presles; 23. Tienen; 24. Tongeren; 25. Velzeke; 26. Wancennes; 27. Heerlen; 28. Nijmegen; 29. Caernarfon; 30. Caerleon; 31. Caersws; 32. Canterbury; 33. Carlisle; 34. Castelford; 35. Chessel Down; 36. Cirencester; 37. Colchester; 38. Corbridge; 39. Culbin Sands; 40. Deansgate, Manchester; 41. Fishbourne; 42. Great Chesterford; 43. Icklingham; 44. Lamyatt Beacon; 45. London; 46. Lullingstone; 47. Lydney Park; 48. Milton Regis; 49. Orpington; 50. Shepton Mallet; 51. South Malling

(Lewes); 52. South Shields; 53. Vindolanda; 54. Wanborough; 55. Winchester; 56. Alteburg-Heftrich; 58. Asberg; 57. Bonn; 59. Cologne; 60. Elsdorf-Esch; 61. Hausweiler-Weilerwist; 62. Krefeld-Gellep; 63. Saalburg; 64. Siesbach; 65. Trier; 66. Zugmantel; 67. Augst; 68. Avenches. Sites with carinated beakers (Isings form 36b) are shown as [□] and globular cups (Isings form 94; Trier 37/38) as [◊].

It appears that black glass vessels were introduced to *Britannia* from a very early stage of the Roman Conquest, but remained a minor part of the glass market until their disappearance in the second half of the 3rd century. This rarity in Roman Britain is in contrast to *Gallia Belgica* and *Germania Inferior*, even though black glass artefacts remained a relatively uncommon glass product there too.

Observations on other types of glass as well as on other materials such as pottery can lead to a better understanding of the distribution of black glass vessels and jewellery in Roman Britain. They can help to set a value on the position of black glass in inter-provincial trade with the northwestern provinces on the Continent in the late 2nd to 4th centuries. Small quantities of black glass produced in *Gallia Belgica* and *Germania Inferior* are present in eastern Britain and more specifically in south-east Britain. This area is the same as the distribution of mould-blown cylindrical glass bottles of the late 3rd and 4th centuries (Isings 1957, form 128; Price 1978, 76–77; 1985, 213) as well as that of a number of pottery imports in late Roman Britain (Millett 1990, 157–180). The south-west of Britain, where black glass artefacts are almost absent, seems a significant market for imports from *Gallia Aquitania* via Normandy and Brittany, where objects of black glass are also more or less absent. These differences may demonstrate the impact of customs barriers on trade and distribution, which are thought to have existed between provinces.

Jewellery

General publications on jewellery in the Roman Empire (Liversidge 1973; Sas and Thoen 2002) demonstrate the use of many different materials. The artisans produced bracelets, beads, finger rings and hairpins with a similar appearance but in all kinds of materials. This *skeuomorphism* is noticeable among many archaeological finds, including both jewellery and vessels (Cosyns and Hanut 2005, 116–117). The contemporaneous occurrence of jet and shale in Romano-British jewellery and black glass on the Continent for similar objects is important, but some types have parallels with jewellery in copper alloys, silver and gold. This observation is worth deeper investigation, but the discussion on the hierarchy of materials in antiquity (Vickers 1996, 48–65; Stern 1997,192–206) will not be reopened here.

In contrast with the paucity of black glass vessels, a wide range of black glass jewellery is known to have been produced in large quantities, in particular during the late Roman period (Loeschke 1925; Spaer 1988; Riha 1990; Spaer 2001; Cosyns *et al*. 2006; Cosyns 2009). Britain has a particular view on all this, not least because of the use of local jet and shale for the production of all kinds of jewellery, made in the same shapes as the continental black glass objects.

Bangles

Most Romano-British glass bangles, ranging in date from the 1st to 4th centuries (Kilbride-Jones 1938; Stevenson 1956; 1976), display a typology which is in clear contrast to those uncovered in large quantities on the continent (Haevernick 1960; De Witte 1977; Riha 1990; Cosyns 2004; Wagner 2006). Kilbride-Jones (1938) established a first chrono-typology for

Romano-British glass bangles, which he thought were of Scottish manufacture. Later work revised this theory (Stevenson 1956; 1976) and emphasized that these artefacts occur on a considerable number of Roman military sites in northern Britain (Price 1985, 214). More recent work has revealed that these bangles are common to the whole of Britain (Price 2004, 233).

The colourful appearance of the Romano-British pieces is in contrast to the monochrome black glass bangles with circular or D-shaped section from the Continent. Various patterns of applied coloured glass threads are identifiable on mainly triangular-sectioned bangles in monochrome translucent blue, blue-green, opaque white, yellow and black glass. Although polychrome examples appear on the Continent too, these are very rare excavation finds and are limited to bangles with an O-shaped section decorated with applied twisted glass threads in opaque white, red and blue glass; examples are waste material from Sainte Menehould-les Houis (Cosyns 2009) and a piece in the Musée National d'Archéologie et Histoire, Luxembourg (inv. no. 1991.1156/88; unpublished). Romano-British glass bangles are almost completely absent on the Continent (Van Lith 1977, 130–134) and continental black glass bangles are rare in Britain and are essentially limited to south-east England (Table 18.1). It is noteworthy that the large, late Roman cemetery at Lankhills, Winchester has no bracelets in black glass although there were many bracelets in copper alloys, iron, jet, shale, ivory and bone (Clarke 1979, 301–314).

The rarity in Britain of black glass jewellery in general, and bracelets in particular, is entirely due to the use of local jet and shale (Allason-Jones 1996). It is important to compare the chrono-typology of jet jewellery with its continental equivalents in black glass. Within the 3rd and 4th centuries very simple objects in black glass must have been cheaper substitutes for jet jewellery. Jet was imported from the Yorkshire region along with other material discussed below, such as gilded copper alloy brooches with conical glass settings, both seen in *limes* forts such as Saalburg, Zugmantel and Alteburg-Heftrich (Böhme 1972). There is a relative concentration of jet in the Rhine region from the middle of the 3rd to the end of the 4th century AD, though it is found in *Germania Inferior* as early as the very end of the 2nd century. One example is the jet and gold bracelet with the portrait of Septimius Severus from Presles (Lefrancq 1988, 30, fig. 6), but jet is restricted to luxury finds in rich graves, *e.g.* the two knives with jet handles decorated with gilded silver from tumulus I at Overhespen (Mariën 1994, 60–61, fig. 23–17/18) and the twisted bracelet from Köln-Lindenthal combining jet and gold (Damm 2002, 62, fig. 36).

Site	Typology	Date (century AD)	Bibliography
Canterbury, Kent	D1	early 5th	Bennett 1980, 406–410
Chatham, Kent	B1	unknown	White 1988, 108, fig. 54.1
Chessel Down, Isle of Wight	unknown	unknown	White 1988, 108, no.2
Chessel Down, Isle of Wight	B5	probably 4th–5th	White 1988, 108, no.3, fig. 54.2
Cirencester	undefined	unknown	Viner 1998, 299
Colchester	A2	unknown	Crummy 1992, 149
Icklingham, Suffolk	unknown	unknown	Fox 1900, 148
Lamyatt Beacon, Somerset	B2	4th	Leech 1986, 293, fig. 24, no.14
London	A1	3rd	Barber and Bowsher 2000, 148, Grave B168, no.2 C <22>
Milton Regis, Kent	B2	unknown	White 1988, 108, nos 4–5, fig. 55.1–2
Orpington, Kent	B5	5th	Tester 1968, 125–150
South Malling, East Sussex	B2	unknown	White 1988, 108, no.7
Wanborough, Wiltshire	A1	4th–5th	Anderson *et al.* 2001, 171, fig. 67, no.143

Table 18.1: List of Romano-British sites with so-called continental 'black' glass bangles. The typology is that defined by Hubert De Witte (1977) and re-adapted in Cosyns 2011.

Johns (1996, 124) suggests that wooden bangles may also have been used in Roman times. Few survive, but there are three examples from the necropolis of Tyre, Lebanon. Two graves both contained an ebony bangle having a rectangular section with lozenges cut at the outside corners and on the inner side, similar to elaborate jet bangles (Hagen 1937, 114, pl. 21–23; Allason-Jones 1996, 30). One has gold leaf decoration preserved on two areas and can be compared to the gold bracelets found in the treasure of Eauze in south-west France (Schaad 1992, 36–39, pl. 2); perhaps the Eauze example was a similar piece, where the wooden core has not been preserved. One of these graves also had a coin of Gordian (241 AD) and the other a coin of Trajan Decius (249–251 AD) (Chéhab 1986, 153–155, pl. XVa; g,3). The coins date both graves to the middle of the 3rd century. The third bangle, in an unspecified wood, is carved all around the section, resembling the twisted decoration found on bangles in materials such as glass and jet, but also copper alloy and gold. It comes from a grave containing a coin of Constance II (c. 351–354 AD) dating the bangle to the 2nd half of the 4th century (Chéhab 1986, 155, pl.XVf,1). These dates agree well with the dating of similar jet and glass bangles from the north-west provinces.

Only two of the British sites with continental types of black glass bangles (Table 18.1) will be considered here: Beer Cart Lane in Canterbury (Bennett 1980, 406–410) and Orpington (Tester 1968, 125–150). The interest of the former site is its particular context while that of the latter is its typological peculiarity.

At Beer Cart Lane was a large pit containing a multiple burial, just below the 5th-century Anglo-Saxon layers; it probably dated from the very end of the Roman period. This is remarkable, first because the grave is in the middle of the town and not in a cemetery outside the settlement, as was normal in Roman society, and secondly because the grave contained a whole family of two adults and two children as well as one or two dogs. As regards the grave goods, the total absence of objects related to the adult male is striking, especially in contrast to the other three individuals. The adult female had eight copper alloy bracelets on the left wrist and another one on the right wrist, which are dated to the 4th century, four copper alloy keys, a small knife and a razor (dated to the mid-4th to mid-5th centuries), three amber beads and ten dark brown or black glass beads. One juvenile is a girl of about 11 years who has a black glass bangle (De Witte/Cosyns type D1; Riha type 3.34; Spaer type A.2), three copper alloy bracelets and fragments of a fourth one, as well as an ivory bracelet, a small copper alloy key and 15 small glass beads, mostly blue and green, characteristic of the 4th-5th centuries. The second juvenile, of uncertain gender, was about 8 years old and only wore two copper alloy bracelets. Other examples, particularly on the Continent, show that mostly children, and in particular female juveniles, wore black glass bracelets, *e.g.* graves from Tawern, near Trier (Kraus 1940, 76–77, fig. 40), Krefeld-Gellep (Pirling 1974, grave 1749, no. 1), Amiens (Dilly and Mahéo 1997, 123, X) and Furfooz (Nenquin 1950, 74). The Amiens grave, found in 1820, contained a lead coffin enclosing the inhumation of a child wearing two octagonal jet bracelets and two plain black glass bracelets with a D-shaped section (De Witte/Cosyns type D1; Riha type 3.34; Spaer type A.2) – erroneously described as jet bracelets – which are typical of the second half of the 4th and the early 5th century. The bath-house of the late Roman hillfort at Furfooz was re-used as a burial place from about the middle of the 4th century AD. Two burials of female juveniles each contained two plain bangles with D-shaped sections in dark green glass that appeared black (Nenquin 1950, 74, nos F6–9, pls X, 7–8; 88; 98).

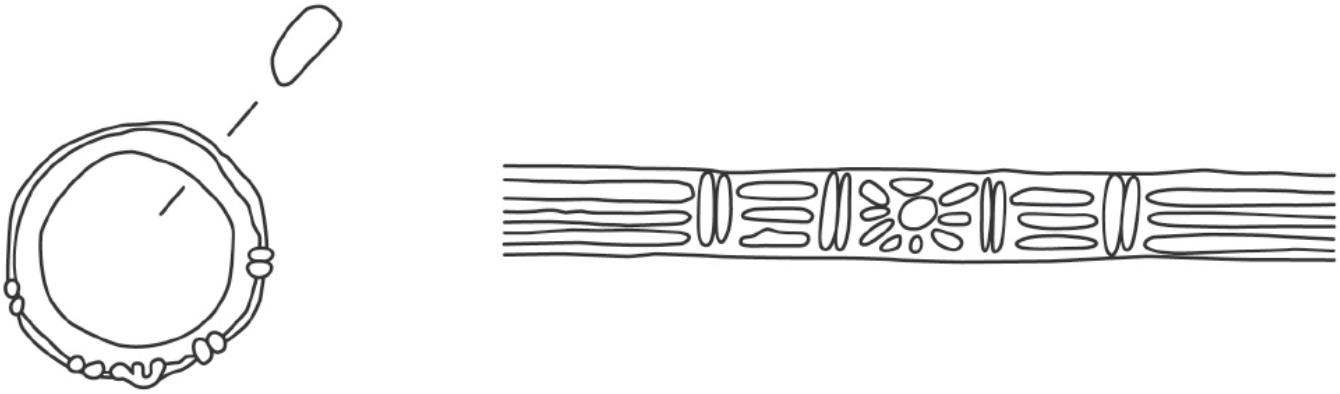

Fig. 18.2: Finger ring from Trou de Han, Han-sur-Lesse. Internal diameter 16.5mm, height 7mm.

The Orpington bangle was found in grave 2 of an early Anglo-Saxon cemetery within a late Roman site. It contained the remains of an inhumed woman aged 30. Although the grave was partly destroyed by grave 3, one fragment of the bangle was thought to be *in situ* beneath the right humerus, suggesting that it was worn just above the elbow. The other fragments were found scattered in the lower grave filling. The unique black glass armlet with pressed decoration reminiscent of copper alloy bracelets is particularly striking. It consists of a continuous single band bordered by broken lines, between which the surface is divided vertically by pairs of parallel lines composed of dashes. Each line consists of six or seven dashes pressed with comb-like implements with pointed teeth. Between each pair of lines is a four-petalled 'flower'.

Finger rings

Finger rings in black glass are fairly common on the Continent, but are less frequent in Britain as, again, glass faced competition from local jet and shale. However, they do occur on some sites in England: a fragment of an undecorated example made from a circular rod is known from the Romano-British small town at Wanborough (*Durocornovium*) (Monk 2001, 165, fig. 65, no. 57) and a second fragment in opaque dark blue glass (Monk 2001, 171, fig. 67, 144) resembles a complete ring from Trou de Han (Fig. 18.2). This ring is decorated with lengthwise ribs stopped by vertical ribs. The space between the two bundles of vertical ribs is filled with a radiant sun, which is likely to have been the case for the Wanborough piece too. Another ring fragment from Fosse Lane, Shepton Mallet has a D-shaped section and is decorated with a repeated geometric design in low relief consisting of two concentric diamonds and between them V-shaped motifs (Price and Cottam 2001, 204, fig. 55, no. 26).

These pieces are unfortunately not from closely datable contexts: the Wanborough fragment is undated and the Fosse Lane piece is dated after the last quarter of the 4th century; the Trou de Han ring comes from an unstratified underwater excavation with 3000 years of deposits from the end of the Late Bronze Age onwards. While there are only a few examples of black glass finger rings from *Britannia*, the Continent has many examples from France (Vitrum 1990, nos 74–78), including Sainte Menehould-Les Houis (Cosyns 2009), and Germany: Bonn-Medizinische Klinik (Hagen 1937, 105–106, 5.1–9; Heimberg 2002, 154–156) and Trier-Palais Kesselstatt (Cosyns 2009). Particularly notable are the finger rings from Bonn-Medizinische Klinik, in black glass, (black) jet and (black) copper alloy.

Beads

Black glass beads are quite rare for the entire Roman period in the north-western provinces and even rarer in *Britannia*, becoming merely moderately popular in late antiquity, at the very end of the Roman period and during the early medieval period, as attested by early Merovingian and early Anglo-Saxon finds (Guido 1999). The earliest examples of Roman black glass beads, globular melon beads with streaks in white opaque glass, are dated to the early to mid 1st century and are considered to be a continuation of an Iron Age tradition within the north-western provinces. The increased production of black glass beads from the late 2nd century Severan period onwards is probably due to the popularity of jet. However, most black glass beads are dated to the 3rd-4th centuries. Margaret Guido discusses some variations of annular and globular beads from British sites but considered the decorated ones to be from the Migration period (Guido 1978, 64–65), a theory she also applies to the analysis of Anglo-Saxon material (Guido 1999) (Table 18.2).

Type	Subtype	Shape	Decoration	Size	Reference
Group 5D	subcategories i-iv	annular; globular	decorated (applied trails in wavy pattern)	small; medium	Guido 1978, 62; 64-65
Group 6	subcategory ix	annular	undecorated	small	Guido 1978, 65; 68
Group 7	subcategory viii	globular	undecorated	small; medium	Guido 1978, 69; 70-71
Roman 1-2		segmented	undecorated		Guido 1978, 91-93
Roman 4-5		cylindrical	undecorated		Guido 1978, 96
Roman 12-13		biconical	undecorated		Guido 1978, 97-98

Table 18.2: Black glass Roman Beads known from Romano-British sites.

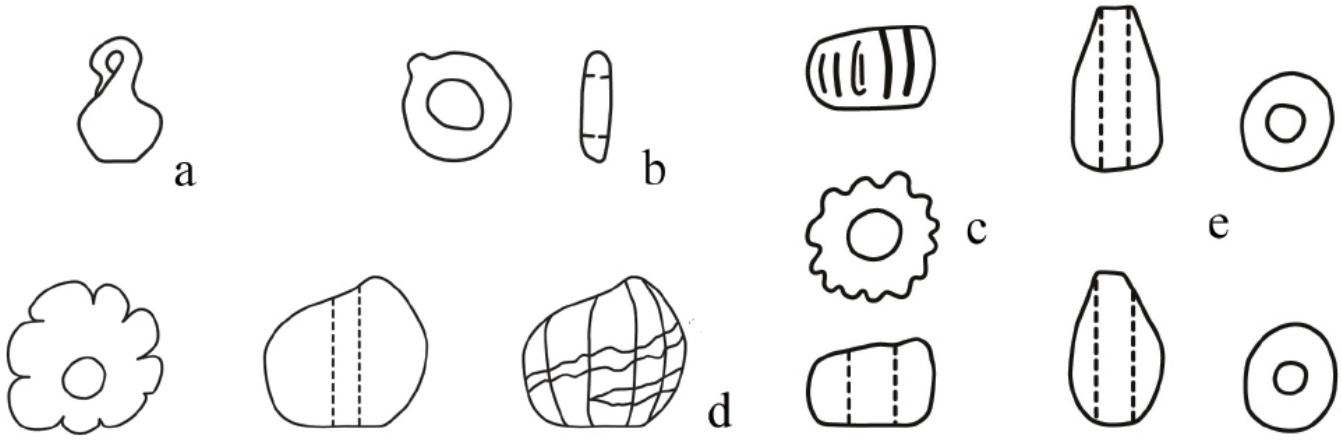

Fig. 18.3: Beads from Tienen-Grijpenveld: a) globular bead, diameter 4.5mm; b) annular bead, external diameter 9.5mm, height 2–3mm; c) small melon bead, max. diameter 10mm, height c. 6mm; d) medium melon bead, max. diameter 22mm, height 13–18mm. Beads from Wancennes: e) two "olive-stone" shaped beads, max. diameter 7mm, height 12mm.

Two segmented beads (Guido Roman type 1–2) come from the Romano-Celtic temple on Lamyatt Beacon (Leech 1986, 293, fig. 24, nos 6–7).

Thirty short cylindrical beads (Guido Roman type 5) from a late 4th to early 5th century necklace from grave 83 at Abbeville which also has thirteen metallic gold beads (Chew 1997, 100, no. 131) can be compared with a necklace from the south-western necropolis at

Tongeren with its 135 short cylindrical beads in black glass together with fourteen metallic gold beads (Sas 2002, 185, no. 113).

Guido does not report any round beads with flattened section (Guido Roman type 17a) or melon beads (Guido Roman type 21–22) in black glass for the British Isles (Guido 1978, 92–100). Some examples uncovered at the large rescue excavation at Tienen-Grijpenveld (unpublished) are equally absent in Britannia:

- A micro annular bead (inv.no. TI 99 TR-16/252) with a diameter of 2.5–3mm and a width of 3mm comes from a 2nd-century AD context. A similar one in opaque red has been recovered from the same site.
- A small globular bead with a goose-head suspension loop (Fig. 18.3a) is a rather rare type but another in blue-green glass is known from Braives (Vilvorder 1997, fig. 101–27).
- A small annular bead (TI 99 TR-16/229) (Guido Group 6:ix) has a diameter of 10mm, a width of 3mm and an opening of 5mm diameter (Fig. 18.3b). Similar beads with comparable dimensions come from the Roman fort at South Shields (Allason-Jones and Miket 1984, 280, 4.47), Corbridge and Culbin Sands (Allason-Jones and Miket 1984, 280, 4.47). An annular bead from the late Roman hillfort of 'Tienne de la Roche' at Éprave in the Belgian Ardennes has the same diameter but has a width of 5–6mm and an opening of 3.5mm (Musée Archéologique, Namur, inv.no. A 4885; unpublished).
- A small melon bead (TI 98 TR-07/00) with a diameter of 10–12mm, a width of 6–8mm and an opening of 5mm (Fig. 18.3c), is similar to those found in the inhumation grave of a child at Krefeld-Gellep, Germany (Pirling 1997, 32, grave 3785, no. 3a) and those from the necklace found in tomb 389 at Maule, France (Arveiller-Dulong 2006, 157, no. 20). Such annular melon beads are very common in 4th-century contexts and attested over a wide area of the Empire.
- A globular melon bead with a decoration of horizontal wavy lines in opaque white glass (TI 99 TR-12/112.2) has a diameter of 18–22mm, a width of 13–18mm and an opening of 5mm diameter (Fig. 18.3d). The Tienen bead comes from a Tiberian-Claudian context like most other examples of such decorated medium sized beads, such as those from Augst, Switzerland (Riha 1990, 91; 161, pl. 39, no. 1343).

Other shapes known in black glass are:

- Two 'tear-drop' shaped beads (Fig. 18.3e), both still attached to a copper alloy earring, from the 2nd-3rd-century cemetery at Wancennes (Bequet 1883, 368–369).
- It is clear that most of the shapes mentioned above are, so far, unrecorded in *Britannia* but black glass beads are definitely not totally absent. A small globular bead formed part of a necklace from tomb 333 from the late Roman cemetery of Lankhills (Winchester), dated to the end of the 4th-early 5th century (Guido 1978, 71). Widespread and typical for the very late Roman period are large, long, slightly biconical, cylindrical and annular beads decorated with unmarvered single or double zigzags. These are rare in the material from Sainte Menehould-Les Houis but abundant at Trier-Palais Kesselstatt (Cosyns 2009).

Hairpins

Although coloured glass hairpins like those from the Roman fort at Vindolanda (Price 1985, 214, no. 88) do occur in *Britannia*, black glass hairpins are absent although they are known on the Continent. Those from Sainte Menehould-Les Houis (Cosyns 2009) are all short types with

an oval or a flattened circular head (Crummy Type 3) but in Britain these types are only known in jet and bone (Crummy 1979).

Settings in brooches

A particular use of black glass is for the setting in the centre of circular and oval gilded copper alloy brooches. The glass gem is a small cone of very strongly-coloured glass, usually appearing black. These are generally dated to the 3rd century (Riha 1979; Johns 1996, 181–182). An oval example with a conical gem in dark blue glass is known from a late 3rd or early 4th-century context at Fishbourne (Cunliffe 1971, 106, fig. 40, no. 43), and those from the Roman fort at Caernarfon (*Segontium*) (Casey *et al*. 1993, 166, no.13) and Wanborough (Butcher 2001, 64–65, fig. 26, nos 137–138) are dated to the 4th century. Numerous examples of this type of particular brooch are known from *Britannia* (Bayley and Butcher 2004, types T270; T271), though examples of these *Punzverzierte ovale Scheibenfibel mit Glaseinlage* are also found on the Continent in the Rhine region, within and beyond the Roman Empire in free Germany (Riha 1979, type 3.17; Böhme 1972, Type 45).

In contrast to the generally simple and abstract design of this type of disc brooch is a very elaborate piece from the Roman cemetery of Wancennes, Belgium (Bequet 1883, 368–369; Mignot 1984, 223–224, fig. 36–18), now in the Musée Archéologique of Namur (Inv. no. A7032), a piece which might reveal what these conical glass settings represent. This brooch is decorated with a thin applied copper alloy sheet, enclosing a central medallion of a Medusa's head in a very dark bottle-green glass that looks black (Fig. 18.4). The outer part of the metal sheet is decorated in *repoussé* with a ring of eyes flanked by two rows of pearls and within this an inscription: PERSEUS CONCIDERA[T] ◦ CAPUD GORG[ON]IS (which can be translated as 'Perseus cut down/off the head of the Gorgon'). A similar gemstone with a cast Medusa head has been retrieved from the late 2nd to 3rd-century AD dated cremation tomb 80 at the Roman cemetery of Wanzoul, Belgium (Destexhe 1989, 76, pl. 37:2). Because the find is a burial gift within an intact tomb, the gem could well have been set in a (now disintegrated) wooden brooch. It is known that the Romans considered the head of Medusa apotropaic (Pailler 1992, 79; 82), fending off evil from the individual, a function adopted later in Christian iconography by Saint George slaying evil personified as a dragon. The gilded brooches with glass settings are seemingly direct imitations of those in gold with a precious gemstone which very seldom occur in the archaeological record, in contrast to their cheaper substitutes.

Counters

Counters are extremely common and were made of all kind of materials, including bone, ivory, stone and pottery (Crummy 1983, 91–97). Large numbers of glass counters are known in various colours, opaque and translucent, mainly monochrome black, white and blue, though polychrome counters occur too (e.g. Harden 1936, 292–294; Allen 2000, 440, fig. 113, no. 134). Glass counters are typically a plano-convex discoid shape with a flat bottom, a convex top and rounded edge (Fig. 18.5).

Counters can be conical, although these occur rarely and are principally limited to materials other than glass. Unusual glass counters come from the late Roman cemetery of the fort at Oudenburg. The six counters from grave 100 combine glass with bone, having two glass layers, a transparent blue-green one on top of an opaque white one, on a base of bone (Mertens and Van Impe 1971, 72, nos 2–9, pl.XI, 2–9).

Like all other glass counters, those made of black glass are widespread throughout the Roman Empire from the Augustan period to the 4th century, although they are said to be more numerous in the western provinces and especially in modern-day France, Germany and Britain (Catalogue Roanne 1987, 103). Focusing on this area, we see a difference between the Continent and *Britannia* even though no detailed survey of the subject is available. The majority of the British material consists of small pieces, while large counters are in the majority on the Continent.

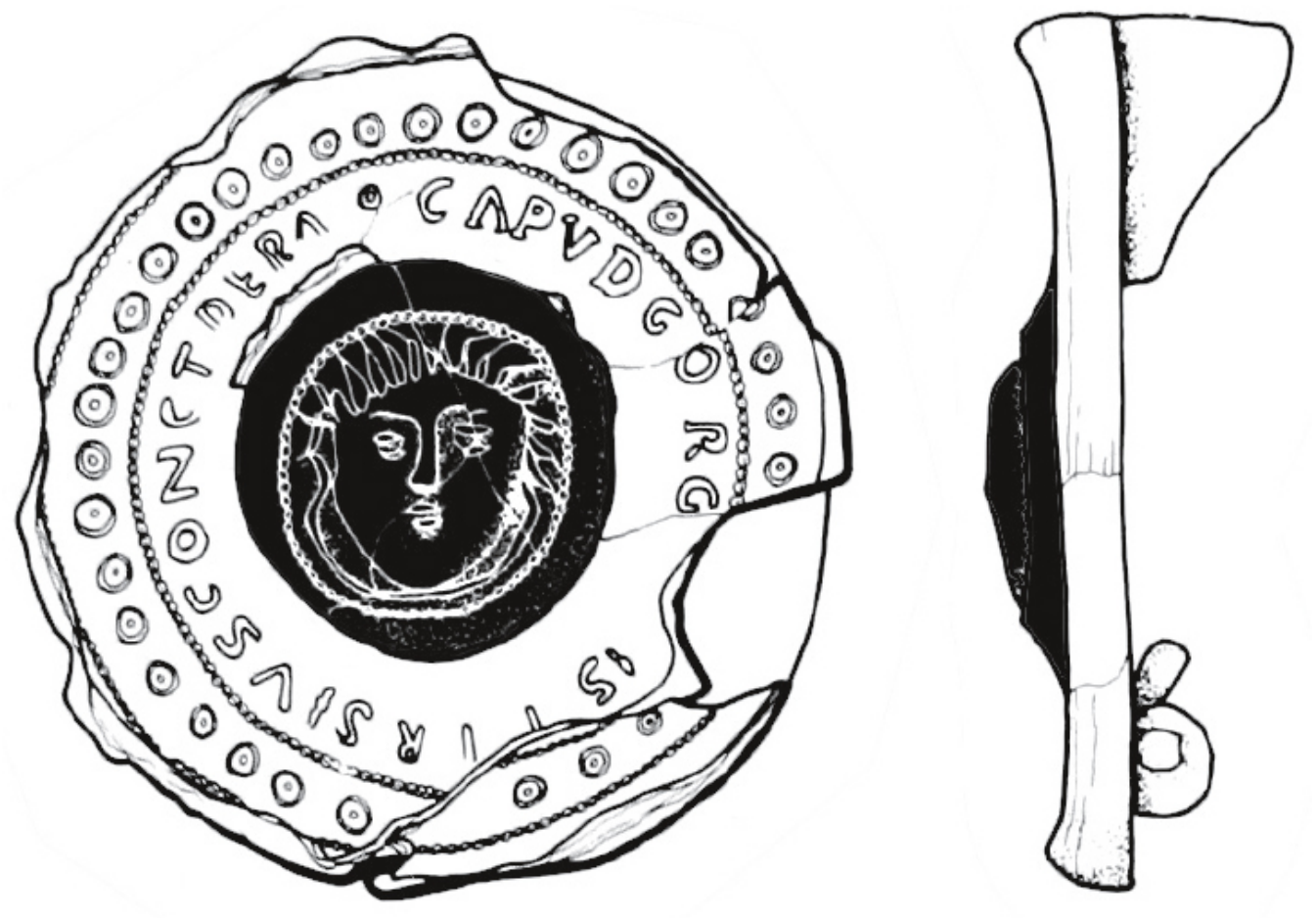

Fig. 18.4: Gilded copper alloy brooch from Wancennes with an inscription and a 'black' glass gem with the representation of Medusa in the centre; brooch diameter 37mm, glass diameter 18mm.

Deep purple, deep olive, bottle green and dark brown glasses were used to produce black counters. Some, coincidentally, seem to be partly made of translucent pale blue-green glass like a counter from Grobbendonk (unpublished), though this is only noticeable when viewed in transmitted light. The black glass counters are mainly monochrome but some have polychrome decoration, *e.g.* wavy concentric circles of white and purple glass in the centre, like the pieces from the very rich tumulus of Cortil-Noirmont (Lefrancq 1989, B13, no. 30). More common are one or more small spots, as on the set of black and white counters from grave 1215 at Krefeld-Gellep (Pirling 1966, 125–126, pls B; 101, no. 3) or the set of counters from grave 51 at Lankhills, Winchester which included black glass counters with either a central blue spot and red spots around, or a central red spot surrounded by blue spots (Clarke 1979, 252, fig. 69a–c, pl. Ib). Other British examples come from a grave at Lullingstone (Liversidge 1973, 350, fig. 133l) and there is a white counter from the Roman temple at Lydney Park, Gloucestershire with a dark red spot in the middle surrounded by two light blue

spots (Casey and Hoffmann 1999, 115; 127, fig. 21,10). Sometimes the decoration is restricted to opaque white dots as on the black glass counter from the late Roman cemetery of Franchimont (Fig. 18.5; Musée Archéologique, Namur, inv. no. A6726; unpublished). Other decoration might have been functional, like the 'T' scratched on the top of the white glass counter found in Cirencester (Charlesworth 1982, 107, fig. 34, no. 94). Although unusual on glass counters, incised letters occur regularly on bone counters like those from Great Chesterford, which are interpreted as possible theatre tickets (Liversidge 1973, 348, fig. 133a–d).

Fig. 18.5: Black glass counter with opaque white spots from Franchimont. Scale divisions 10mm.

Glass counters are commonly divided into two categories: the small ones with a diameter of 10–20mm are generally called counters and the large ones with a diameter of 27–32mm are described as gaming pieces (Price 1985, 214). Their height is between 6 and 7mm, though some are 5 or 8mm high (Harden 1936, 292–294). Both sizes occur in the same contexts as the Wanborough counters illustrate (Monk 2001, 172). At Caerleon, half of the 48 counters come from dated contexts: five from the last quarter of the 1st century, thirteen from the early 2nd century and six from the period AD 160–230 (Brewer 1986, 156). In all three periods a mix of small and large counters is present, making this material apparently useless for chronological purposes. Small counters occur on a wide variety of sites in Britain throughout the Roman period and those in opaque white and black glass appear especially on military sites of the 1st and 2nd century (Price 1985, 214). These small counters, on the contrary, are rare but present on the Continent, with examples from Tienen (Cosyns *et al.* 2006, 33, fig. 1b), Penteville (Plumier 1986, 82–83, fig. 56–31) and Franchimont

(unpublished). Conversely, the large counters which are common on the Continent are unusual in *Britannia*.

A number of glass counters have an atypical, elongated ovoid shape and an irregular bottom surface, for example the material from the legionary fortress baths at Caerleon (Brewer 1986, 155) or Colchester (Crummy 1983, 92, fig. 95). Probably this variation of the basal surface is because of different traditions of making glass counters. The irregular surface is possibly the result of a contact with an uneven surface, such as for instance a coarse sandstone, during the annealing process, or because of sand dusted over a smooth surface to prevent adhesion, while the very smooth basal surface must be the result of remelting shaped pieces in the furnace, on a smooth (stone) plate, which cooled gradually, maintaining the same temperature as the glass artefact.

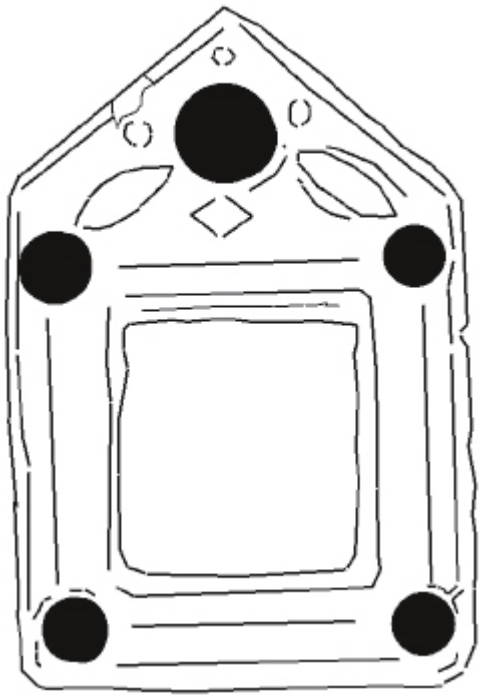

Fig. 18.6: A late Roman mirror in plaster decorated with black glass counters, height 58mm (mirror), 153mm (frame).

The latter technique is described by Pliny, who explained the production of black glass counters:

> 'Pieces of broken glass can, when heated to a moderate temperature, be stuck together, but that is all. They can never again be completely melted except into globules separate from each other, as happens in the making of the glass pebbles (calculi) that are sometimes nicknamed "eyeballs" (oculi) and in some cases have a variety of colours arranged in several different patterns.' Pliny, *NH*XXXVI, 199 (Eichholz 1962)

Although Pliny the Elder refers to the manufacture of *calculi* in all kinds of colours by the recycling of broken glass and naming of them as *oculi* for gaming boards (see above), these counters have undoubtedly been used for multiple purposes.

Notable examples of sets of gaming pieces include twenty counters in different colours, sizes and materials (10 glass, 10 bone) from a mid 1st-century grave at Moers-Schwafheim, near the military fortress of *Asciburgium* (Kraus 2005, 389); the small counters (15 white and 15 brown) from a 4th-century grave at Lullingstone, found on top of a lead coffin together with the remains of a wooden games board (Liversidge 1973, 350, fig. 133l); the 24 glass

counters (11 white and 13 black) found with four bone dice within a wooden box in grave B435 in the east cemetery of London (Barber and Bowsher 2000, 135, fig. 97; 193–195); and the set from Krefeld-Gellep mentioned above. Such sets are only rarely found as grave goods as most often only a single plano-convex counter occurs in a grave. Possibly this is an example of *pars pro toto* and should be interpreted as symbolic, but when this phenomenon occurs only in cremation burials, it is more likely to be the remains of a burial gift placed on the pyre.

Glass counters could have been used as counting pieces or *calculi* with a portable counting board, *abacus* or *quinarius*, which included 24 counters (Schärlig 2003, 518–519). The large numbers of glass counters, concentrated in one place in the Pompeian house with the Indian statue, Insula 8.5 (Fontaine 2009), were probably connected to a set of *abaci* used during arithmetic lessons. This plausible interpretation cannot be proved but suggests the room might have functioned as a schoolroom (Casson 1998, 17).

Counters could also have a decorative function. One example is a late Roman mirror in a plaster frame from the Musée du Verre, Charleroi (Renard 1999, 51, no.11) which has one large and four small black glass counters at the corners (Fig. 18.6), while a large number of counters were inserted in the stucco ceilings of the *Domus Transitoria* in Rome (Bacchelli *et al*. 2000, 86).

Conclusion

Black glass was used in the Roman Empire during the middle of the 1st century AD and for a second time from the middle of the 2nd to the middle of the 3rd century for the production of vessels, and as late as the early 5th century for the manufacture of jewellery. During the 1st century it was more or less restricted to counters and vessels, with diversification into objects like hairpins, bracelets, beads, pendants, stirring-rods being characteristic of the later 2nd to early 5th centuries. Besides the presence of black glass gaming counters on most Roman sites all over the Empire, bangles, rings and even beads seem to have been common products on the Roman market. Black glass vessels, on the other hand, are mostly restricted to the north-western provinces, with only a marginal occurrence in Britain. Recent work mapping these black glass vessels shows that black glass vessels from the 1st century AD are very rare and mainly restricted to forts in the Rhine region and Britain and some large centres. For the 2nd to 3rd centuries a concentration in the *Civitas Tungrorum* in *Germania Inferior* is apparent, yet similar material is known from neighbouring areas. A more detailed analysis of these distribution maps of vessel forms has the potential to provide further information on distribution and trade.

Black glass was used on the Continent in *Gallia Belgica* and *Germania Inferior* for the production of a whole range of jewellery, while in the British Isles jet was used for making similar objects. The published excavation reports of Romano-British sites lead to the conclusion that black glass objects are absent or very scarce, and therefore plays only a minor part in the use of glass through the Roman period. A study of *skeuomorphism* between jet, shale, copper alloy and glass objects might therefore provide information on the socio-economic importance of black glass artefacts. The black glass bracelets and beads in *Britannia* are all found on sites in south-east England in the vicinity of late Roman structures, even though many seem to have been recorded in Anglo-Saxon contexts.

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